2017 National Electrical Safety Code® (NESC®)

C2-2017

NESC 100TH ANNIVERSARY EDITION

IEEE

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

Accredited
Standards
Committee
C2-2017

National Electrical Safety Code®

Secretariat
Institute of Electrical and Electronics Engineers, Inc.

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American National Standards Institute

2017 Edition

Abstract: This Code covers basic provisions for safeguarding of persons from hazards arising from the installation, operation, or maintenance of (1) conductors and equipment in electric supply stations, and (2) overhead and underground electric supply and communication lines. It also includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment. The Code is applicable to the systems and equipment operated by utilities, or similar systems and equipment, of an industrial establishment or complex under the control of qualified persons. This Code consists of the introduction, definitions, grounding rules, list of referenced and bibliographic documents, and Parts 1, 2, 3, and 4 of the 2017 Edition of the National Electrical Safety Code.

Keywords: communications industry safety; construction of communication lines; construction of electric supply lines; electrical safety; electric supply stations; electric utility stations; high-voltage safety; operation of communications systems; operation of electric supply systems; power station equipment; power station safety; public utility safety; safety work rules; underground communication line safety; underground electric line safety

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Foreword

This foreword is not a part of Accredited Standards Committee C2-2017, National Electrical Safety Code.

This publication consists of the parts of the National Electrical Safety Code® (NESC®) (Accredited Standards Committee C2) currently in effect.

Substantive changes in the 2017 Edition are identified by a change bar in the left-hand margin. In several cases, rules have been relocated without substantive changes in the wording. In these cases, only the rule numbers have been indicated as having been changed.

2017 Edition

Major changes in the 2017 Edition include (1) adding definitions for *communication* and *supply space*, (2) adding exceptions for underground cable grounding requirements, (3) revising and reorganizing the guy insulator placement rules, (4) revising and reorganizing the Grades of Construction application rules, and (5) revising the Part 4 worker safety rules to align with the changes in the OSHA work rules.

In Section 1, the Purpose rule was reorganized to clarify who and what the rules of the Code are meant to safeguard. The Scope rule was revised to include wind and solar energy as one of the sources for generating electricity. Two major revisions were added to the Application Rule (Rule 013). The first is the addition to Rule 013B3 clarifying which edition of the Code applies after an installation has been updated to a subsequent Code edition. The second revision concerns the addition of new facilities to an installation that does not meet Code rules.

Definitions for terms no longer used in the Code were deleted. Definitions added include *communication equipment, communication space, electric supply equipment, insulator, limited access highways, supply space, wind span,* and *weight span.*

In Section 3 (References), standards were added, updated, or deleted if no longer referenced in the Code. Appendix E (Bibliography) was also updated.

In Rules 092C1 and 096C, exceptions were added to exempt the four-grounds-in-each mile requirement under specific limiting conditions. In Rule 094B, stainless steel was included with nonferrous metals. Many of the grounding electrodes described in the rule are now considered to be equivalent. The exception allowing other dimensions and configurations if supported by a qualified engineering study was expanded to cover more types of electrodes.

In Part 1, major revisions to *electric supply stations* consisted of additions to Rule 110A that address safety sign locations, adjoining fence restrictions, and impenetrable fence modifications. Rule 114 pertaining to fire-extinguishing equipment was deleted. Rule 124A1 was revised to require the electric supply station clearance values in Table 124-1 and Table 110-1 to have appropriate atmospheric correction factors applied for altitudes above 1000 m (3300 ft).

Guy insulator Rules 215C2 to 215C8 were rewritten and reorganized to make them easier to understand and apply with the voltage transfer rules associated with guy insulators being removed. Voltage 'adder' calculations for vertical clearances between conductors carried on different supporting structures specified in Rule 233C will now require using a phasor relationship when determining the voltage between the conductors involved. Clearances of overhead lines from aboveground swimming pools with and without decks were added to Rule 234E1. All the rules associated with the clearances of antennas from supply and communication lines were placed into one rule, Rule 235I, and Rule 238E will now require a 1 m (40 in) vertical clearance between luminaires that are not effectively grounded and communication cables and equipment located in the communication space.

NOTE—Definitions of supply and communication space are now in Section 2.

In general, the rules in Section 24 were edited to provide greater clarity and easier reading. For example, Rule 241C was converted from a paragraph format to a bulleted format and a note was added to Rule 240 to point out that requirements for emergency and temporary installations are addressed in Rule 014.

Although the content of Table 242-1 remains largely the same, the order of the columns and rows was changed to follow a more intuitive progression. Take note that for crossing supply conductors exceeding 22 kV, the table value is now shown as Grade B and Footnote 3 allows a reduction to Grade C if the supply circuits will be promptly de-energized. Previously, the Table 242-1 showed a requirement of Grade C with a footnote stating that Grade B was required if the supply would not be promptly de-energized. Footnote 11 was also added to Table 242-1 to specify that Grade N construction can be used for dielectric fiber-optic supply cables when certain grounding requirements are met.

Rule 250D has additional language that clarifies the objects that have ice added to them for loading analysis and those objects where ice is not added. Rule 261H has an added requirement that the potential for damage from Aeolian vibration must be considered for all conductors. In addition, when limiting tension is the only method applied for mitigation, initial and final tension limits are specified.

Several changes to requirements for insulators were adopted into Section 27. The industry has developed new insulator ratings over the last 10 years and the changes in Section 27 were made to coincide with manufacturers' current rating practices.

Separate allowed percentage of strength ratings are now specified for Rule 250B loads versus Rules 250C and 250D loads. In addition, new classifications were adopted to differentiate distribution and transmission insulators and the allowable values were changed for those insulators that have a new rating methodology.

In Part 3, rules requiring underground conductor neutrals and any other conductors that are intentionally grounded were revised to require grounding where they are exposed to personnel contact.

Rule 354D contains exceptions that allow grounding and bonding between underground communication and supply cables at equipment locations in lieu of grounding and bonding the underground cable between equipment locations.

The rules covering burial depths for direct buried underground cables and duct not part of a conduit system were revised to require burial depths; an exception was added if the requirement cannot be met.

The conductance requirement in the random separation between supply and communication rules was deleted.

Several noteworthy changes were made to Part 4. Specifically, revisions to Rule 410A, Rule 420K, Rule 441, and the associated tables were adopted to align these work rules with changes to OSHA federal regulations (Title 29 of the Code of Federal Regulations) published in April 2014.

Rule 410A3 was revised to recognize the possible necessity to protect the head, face, hand, and feet of employees working on or near energized lines, parts, or equipment at voltages 50 V to 800 000 V (ac) and also includes a recommendation for voltages 50 V to 250 V (dc).

Rule 420K was revised and expanded to address and provide guidance fall protection and fall arrest equipment and its use.

Rule 441 (and the associated tables) was extensively revised to: address situations where the grounding of lines operating at 600 V (ac) or less is impractical; include definitions for *reach* and *extended reach*; address work on exposed grounded lines 301 V to 72.5 kV (ac); clarify the use of the Rubber Glove Work Method for lines 301 V to 72.5 kV (ac); and address work position when performing live-line work on lines 72.5 kV and above. Table 441-1 was revised to include material changes to the default minimum approach distance values for ac live-line work for lines 72.6 kV and above. Corresponding to the revisions to Rule 441A4, new Table 441-2, Table 441-3, and Table 441-4 were added to supplement Table 441-1 where the per unit transient overvoltage value has been determined through an engineering analysis.

2012 Edition

In the 2012 Edition, major changes include: an updated scope, application, and definitions; greatly simplified minimum approach tables and voltage exposure for arc flash; the addition of K factor for wire tension; and added clarification of the ungrounded portions of guys around swimming pools. Consistency to the application of the terms *grounded* and *effectively grounded* was applied. Rule 313 was reworded to include the recording and correction of conditions, not just defects, which affects compliance with the Code. A new rule, Rule 355, was added that contains rules for duct not part of a conduit system. Two significant changes were made to the work rules in Part 4, specifically in the Rule 441 minimum approach distanced tables, and also in Rule 410A3 on arc flash exposure.

2007 Edition

The major revisions for the 2007 Edition included grounding, moving sag calculations to Section 23, moving guy and span wires insulator rules to Section 21, phasing out of the alternate method for load factors and strength factors, flammable materials transported, phase-to-phase cover-up, and minimum approach distance tables.

2002 Edition

In the 2002 Edition, several changes were made that affected all or several parts of the Code. Particularly, this edition clarifies interfaces between the NEC and NESC with regard to Code jurisdiction in the area of streetlights and area lights. Also included is clarification for situations between utility workers and their authorized contractors and installations on industrial complexes.

1997 Edition

In the 1997 Edition, the most notable general change that took place is that numerical values in the metric (SI) system are shown in the preferred position, with customary inch-foot-pound values (inside parentheses) following. A bibliography, Appendix B, which consists of a list of resources identified in notes or recommendations, was added. Changes were made to rules affecting grounding, electric supply stations, and overhead lines, particularly with regard to clearance rules applicable to emergency and temporary installations. Strength requirements contained in Sections 24, 25, and 26 were revised completely. Underground line requirements for random separation for underground lines of direct-buried cables were modified. The requirement for cable identification marking by means of sequentially placed logos was introduced. Work rules added a requirement that warning signs and tags comply with applicable ANSI standards, tagging requirements were clarified with regard to SCADA, and extensive requirements for fall protection were added.

1993 Edition

In the 1993 Edition, changes were made in the rules applicable to emergency and temporary installations. In Section 9 and Parts 1, 2, and 3, rules were extended or clarified to include HVDC systems. The requirements for random separation of direct-buried supply and communications systems were modified for consistency and clarity, as was the rule in Part 4 on tagging electric supply circuits.

1990 Edition

The 1990 Edition included several major changes. General rules were revised. A significant change to the method for specifying overhead line clearances was made and the rationale added as Appendix A. Requirements for clearances of overhead lines from grain bins and an alternate method for determining the strength requirements for wood structures was added. Rules covering grounding methods, electric supply stations, underground lines, and work rules were changed.

1987 Edition

The 1987 Edition was revised extensively. Definitions were changed or added. Requirements affecting grounding methods, electric supply stations, overhead line clearances and loading, underground lines, and work rules were revised.

1981 Edition

The 1981 Edition included major changes in Parts 1, 2, and 3, minor changes in Part 4, and the incorporation of the rules common to all parts into Section 1. The 1984 Edition was revised to update all references and to list those references in a new Section 3. Converted metric values, for information only, were added. Gender-related terminology was deleted. Section 1—Introduction, Section 2—Definitions, Section 3—References, and Section 9—Grounding Methods, were made applicable to each of the Parts 1, 2, 3, and 4.

Early Editions

The former practice of designating parts by editions has not been practical for some time. In the 1977 Edition, Parts 1 and 4 were sixth editions, Part 2 was a seventh edition, Part 3 was a revision of the sixth edition, Part 2, Section 29, did not cover the same subject matter as the fifth edition, and Part 3 was withdrawn in 1970. In the 1987 Edition, revisions were made in all parts, and revisions to all parts have been made in subsequent editions. It is therefore recommended that reference to the NESC be made solely by the year of the published volume and desired part number. Separate copies of the individual parts are not available.

Work on the NESC started in 1913 at the National Bureau of Standards (NBS), resulting in the publication of NBS Circular 49. The last complete edition of the Code (the fifth edition, NBS Handbook H30) was issued in 1948, although separate portions had been available at various times starting in 1938. Part 2, Definitions and the Grounding Rules, sixth edition, were issued as NBS Handbook H81, ANSI C2.2-1960, in November 1961, but work on other parts was not active again until 1970.

In 1970, the C2 Committee decided to delete the Rules for the Installation and Maintenance of Electric Utilization Equipment (Part 3 of the fifth edition), now largely covered by the National Electrical Code® (NEC®) (NFPA 70®, 2011 Edition), and the Rules for Radio Installation (Part 5 of the fifth edition) from future editions. The Discussion of the NESC, issued as NBS Handbook H4 (1928 Edition) for the fourth edition of the NESC and as NBS Handbook H39 for Part 2 of the Grounding Rules of the fifth edition, was not published for the sixth edition.

The Institute of Electrical and Electronics Engineers, Inc., was designated as the administrative secretariat for C2 in January 1973, assuming the functions formerly performed by the NBS. Comments should be sent to the Secretary, National Electrical Safety Code Committee, through the following online comment form:

Secretary
National Electrical Safety Code Committee
Institute of Electrical and Electronics Engineers, Inc.
http://standards.ieee.org/contact/form.html

Interpretations

Previously rendered interpretations of the NESC can be found at http://standards.ieee.org/about/nesc/interps.html.

The Interpretations Subcommittee was established to prepare replies to requests for interpretation of the rules contained in the Code. Requests for interpretation should state the rule in question, as well as the conditions under which it is being applied. Interpretations are intended to clarify the intent of specific rules and are not intended to supply consulting information on the application of the Code. Requests for interpretation should be submitted using the NESC Interpretation Request Form on the NESC home page: http://standards.ieee.org/about/nesc/interps.html.

If the request is suitable for processing, it will be sent to the Interpretations Subcommittee. After consideration by the committee, which may involve many exchanges of correspondence, the inquirer will be notified of its decision. Decisions are published regularly and may be accessed online at no cost at http://standards.ieee.org/about/nesc/interps.html.

The NESC as written is a voluntary standard. However, some editions and some parts of the Code have been adopted, with and without changes, by some state and local jurisdictional authorities. To determine the legal status of the NESC in any particular state or locality within a state, the authority having jurisdiction should be contacted.

Change proposals and comments for the 2022 Edition of the NESC will be submitted to the NESC Secretary online. For information on how this electronic revision process will take place and for updates and complete information on the NESC, please visit the National Electrical Safety Code on the IEEE Standards website at http://standards.ieee.org/about/nesc/index.html.

Acknowledgments

On behalf of the National Electrical Safety Code (NESC) Committee, the IEEE Standards Association would like to express thanks and gratitude to Michael J. Hyland for his 10-year tenure as Chair of the NESC, from 2006 to 2016. Mike has served with an enthusiasm and leadership unsurpassed in the NESC. The support by the American Public Power Association and its membership for Mike in his role as NESC Chair is sincerely appreciated.

On behalf of the NESC Committee, the IEEE Standards Association gratefully thanks James R. Tomaseski for his 10-year tenure as Vice Chair of the NESC.

Beginning 1 September 2016, the NESC Committee looks forward to leadership for the next Code edition by welcoming Nelson G. Bingel, III, Osmose Utilities Services, as Chair of the NESC, and Danna Liebhaber, Bonneville Power Administration, as Vice Chair of the NESC.

NESC Main Committee Membership

At the time this Code was approved, Accredited Standards Committee C2 had the following membership:

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James R. Tomaseski, *Vice Chair*
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		Stephen Cantrell	Tennessee Valley Authority
WAPA	Patrick Nies		Western Area Power Administration, U.S. Department of Energy

NESC Subcommittee 1
Purpose, Scope, Application, Definitions, and References
Sections 1, 2, and 3

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	Ewell T. Robeson	SC2	Duke Energy
D. J. Christofersen		SC3	CeCe
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	Mickey B. Gunter	SC4	Georgia Power Company, Consultant
Nelson G. Bingel, III		SC5	Osmose Utilities Services, Inc.
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	Samuel Stonerock	SC8	Southern California Edison Co.

AAR—Association of American Railroads
AEIC—Association of Edison Illuminating Companies
AISI—American Iron and Steel Institute
APPA—American Public Power Association
APTA—American Public Transit Association
ATIS—Alliance for Telecommunications Industry Solutions
AWPA—American Wood Preserves Association
BPA—Bonneville Power Admin., U.S. Dept. of Energy
EEI—Edison Electric Institute
EIA—Electronic Industries Association
IBEW—International Brotherhood of Electrical Workers
IEA—Infrastructure Energy Alternatives
IEC—Independent Electrical Contractors
IEEE—Institute of Electrical and Electronics Engineers, Inc.
IMSA—International Municipal Signal Association
NARUC—National Association of Regulatory Utility Commissioners
NAWPC—North American Wood Pole Council
NCEMC—North Carolina Electric Membership Corporation
NCTA—National Cable Television Association
NECA—National Electrical Contractors Association
NEMA—National Electrical Manufacturers Association
NRECA—National Rural Electric Cooperative Association
NSC—National Safety Council
NSPE—National Society of Professional Engineers
RUS—Rural Utilities Services, U.S. Dept. of Agriculture
SCTE—Society of Telecommunication Engineers
SEEX—Southeastern Electric Exchange
SEIA—Solar Energy Industries Association
TVA—Tennessee Valley Authority
TWC—Treated Wood Council
WAPA—Western Area Power Administration, U.S. Dept. of Energy

NESC Subcommittee 2—Grounding Methods
Section 9

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Ewell T. Robeson, *Secretary*

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Ewell T. Robeson		EEI	Duke Energy
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	Ron Wellman	EEI	American Electric Power
David Mullen		IBEW	International Brotherhood of Electrical Workers
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John Dagenhart		IEEE/PES/T&D	Dagenhart Consulting Services
Steven Johnson		NCTA	Johnson Telecomm LLC
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Roger J. Montambo		NEMA	Galvan Industries
Bob Dew		NRECA	Hi-Line Engineering
	Robert D. Saint	NRECA	National Rural Electric Cooperative Association
Ted Pejman		RUS	USDA, Rural Utilities Service
	Trung Hiu	RUS	USDA, Rural Utilities Service
Timothy Cooke		SCTE	Times Fiber Communications, Inc.
Keith Reese		SEEX	Georgia Power Company
	John Bruce	SEEX	Dominion Virginia Power

NESC Subcommittee 3—Electric Supply Stations
Sections 10–19

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David J. Marne, *Secretary*

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	Timothy Jyrkas	EEI	Xcel Energy
	Kenneth Posey	EEI	American Electric Power
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Drew Szabo		IEA	Infrastructure Energy Alternatives
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D. J. Christofersen		IEEE/PES/SUB	CeCe
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For the 2022 Edition, David J. Marne assumes the position of Subcommittee 3 Chair, and Gregory Wolven assumes the position of Subcommittee 3 Secretary.

NESC Subcommittee 4—Overhead Lines—Clearances
Sections 20, 21, 22, 23

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Lawrence M. Slavin		ATIS	Outside Plant Consulting Services, Inc.
	Dennis Henry	ATIS	Ericsson
Danna Liebhaber		BPA	Bonneville Power Administration
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Mickey B. Gunter		EEI	Engineering Consultant
Alan Kuipers		EEI	Consumers Energy
Jeffrey Steiner		EEI	National Grid
Barrett Thomas		EEI	American Electric Power
	Frank Tucker	EEI	American Electric Power
	Jeffery Hall	EEI	Florida Power & Light
	David D'Hooge	EEI	Commonwealth Edison Co.
David Mullen		IBEW	International Brotherhood of Electrical Workers
Marc Candels		IEC	Candels Consulting
Jason Jenks		IEEE/IAS	Intermountain Rural Electric Assoc
	Jason Hoskins	IEEE/IAS	Ulteig Engineers
Douglas Proctor		IEEE/PES/T&D	Proctor Engineering Services
Darren Gill		NARUC	Pennsylvania Public Utility Commission
	Steve Mace	NCTA	National Cable & Telecommunications Association
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	Robert Harris	NRECA	National Rural Electric Cooperative Association
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	Norris Nicholson	RUS	USDA, Rural Utilities Service
Joseph J. White		SEEX	BGE
	Branch Davis	SEEX	Entergy Corporation
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NESC Subcommittee 5—Overhead Lines—Strength and Loading
Sections 24, 25, and 27

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Joseph Rempe		APPA	Tacoma Power
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	Jason Rollins	NAWPC	H. M. Rollins Company, Inc.
Jacob Joplin		NCEMC	Carteret-Craven Electric Cooperative
	Russell Guerry	NCEMC	Edgecombe-Martin County EMC
Steven Johnson		NCTA	Johnson Telecomm LLC
	Steve Mace	NCTA	National Cable & Telecommunications Association
Robert Harris		NRECA	National Rural Electric Cooperative Association
Robert S. Fuller		NSPE	Texas-New Mexico Power Co.
	Grant Glaus	NSPE	Columbia Rural Electric Association
Otto J. Lynch		Power Line Systems	Power Line Systems, Inc.
Thomas Haire		REMC	Rutherford EMC
Wilson Johnson		RUS	USDA, Rural Utilities Service
	Norris Nicholson	RUS	USDA, Rural Utilities Service
Timothy Cooke		SCTE	Times Fiber Communications, Inc.
Frank Agnew		SEEX	Alabama Power
Wade Shultz		SEEX	Alabama Power Company
	David West	SEEX	Duke Power Company

NESC Subcommittee 5 *(continued)*

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	John Trentham	SEEX	Southern Company
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	Stephen Cantrell	TVA	Tennessee Valley Authority
Jim Fixsen		TWC	Bell Lumber & Pole
	Bob Reisdorf	TWC	Laminated Wood Systems, Inc.
Douglas Hanson		WAPA	Western Area Power Administration, U.S. Department of Energy

NESC Subcommittee 7—Underground Lines
Sections 30–39

Charles C. Bleakley, *Chair*
Lauren E. Gaunt, *Secretary*

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Lawrence M. Slavin		ATIS	Outside Plant Consulting Services, Inc.
Trevor Bowmer		ATIS	Ericsson
	Dennis Henry	ATIS	Ericsson
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Donald Guinn		EEI	Progress Energy
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	Jonathan Gonynor	EEI	National Grid
David Mullen		IBEW	International Brotherhood of Electrical Workers
Richard S. Vencus		IEEE	United Illuminating Company
Jorge Camacho		NARUC	Public Service Commission of the District of Columbia
	Steve Mace	NCTA	National Cable & Telecommunications Association
James R. Tomaseski		NECA	Wilson Construction Company Inc.
Robert Emgarten		NRECA	National Rural Electric Cooperative Association
	Robert D. Saint	NRECA	National Rural Electric Cooperative Association
David J. Marne		NSPE	Marne and Associates, Inc.
Trung Hiu		RUS	USDA, Rural Utilities Service
	Donald Junta	RUS	USDA, Rural Utilities Service
Timothy Cooke		SCTE	Times Fiber Communications, Inc.
Charles C. Bleakley		SEEX	Georgia Power Company, Consultant
Mickey B. Gunter		SEEX	Georgia Power Company, Consultant
	Keith Reese	SEEX	Georgia Power Company
	Lee Welch	SEEX	Southern Company

NESC Subcommittee 8—Work Rules
Sections 40–43

James R. Tomaseski, *Chair*
Samuel Stonerock, *Secretary*

Principle	*Alternate*	*Organization represented*	*Employer*
Bill McGough		AEIC	Alabama Power Company
	Bernie D. (Donnie) Bell	AEIC	Gulf Power Company
Brent McKinney		APPA	City Utilities of Springfield
	Kevin Dody	APPA	City Utilities of Springfield
Trevor Bowmer		ATIS	Ericsson
	Dennis Henry	ATIS	Ericsson
Michael Granata		EEI	Appalachian Power Company
Tommy Russell		EEI	Southwestern Electric Power Company
Samuel Stonerock		EEI	Southern California Edison Co.
	Patrick Geoffrey	EEI	PG&E
	Stephen Barnard	EEI	Dominion Virginia Power
	Thuy Nguyen	EEI	American Electric Power
David Mullen		IBEW	International Brotherhood of Electrical Workers
John Masarick		IEC	Independent Electrical Contractors
	James C. Tuggle	IEC	Malpaso Group Inc.
Lawrence Schweitzer		IEEE	The L. E. Myers Company
Thomas Verdecchio		IEEE	PSE&G (retired)
Stephen Poholski		NECA	Newkirk Electric
	James R. Tomaseski	NECA	PAR Electrical Contractors, Inc.
Mark Zavislan		NRECA	Ohio Rural Electric Cooperatives, Inc.
	Robert Harris	NRECA	National Rural Electric Cooperative Association
Steven Theis		NSC	PSE&G
Troy Little		NSPE	Brooks & Jackson, Inc.
	F. M. Brooks	NSPE	Brooks & Jackson, Inc.
Albert Smoak		NSPE	Southwestern Electric Power Company
Brian Erga		NWPPA	ESCI Inc.
David M. Wallis			Emeritus
Norris Nicholson		RUS	USDA, Rural Utilities Services
Charles Shaw		SEEX	Alabama Power Company
Bruce Gurley		SEEX	Duke Energy
	Keith Wallace	SEEX	Alabama Power Company
	Corey Ziegler	SEEX	Duke Energy
Charles W. Grose		Self	Consultant
Edward Hunt		WAPA	Western Area Power Administration, U.S. Department of Energy
	Patrick Nies	WAPA	Western Area Power Administration, U.S. Department of Energy

NESC Executive Subcommittee

Michael J. Hyland, *Chair*
James R. Tomaseski, *Vice Chair*

Name	*Organization*	*Employer*
Michael J. Hyland	APPA	American Public Power Association
Lawrence M. Slavin	ATIS	Outside Plant Consulting Services, Inc.
Leon Kempner	BPA	Bonneville Power Administration
Edward Harrel	EEI	Oncor Electric Delivery Company
Eric K. Engdahl (Alternate)	EEI	American Electric Power
Nelson G. Bingel, III	IEEE	Osmose Utilities Services, Inc.
James R. Tomaseski	NECA	National Electrical Contractors Association
Robert Harris	NRECA	National Rural Electric Cooperative Association

NESC Interpretations Subcommittee

Donald E. Hooper, *Chair*

Name	*Employer*	*Part*	*Section*
Charles C. Bleakley	Georgia Power Company	G	
D. J. Christofersen	CeCe	1	
Allen L. Clapp	PCU Training Center	G	
Alton L. Comans	Alabama Power Company	1	9
John Dagenhart	Dagenhart Consulting Services	G	
Eric K. Engdahl	American Electric Power	G	
Bruce Freimark	American Electric Power	2	
Charles W. Grose	Consultant	4	
Mickey B. Gunter	Engineering Consultant	G	
Donald E. Hooper	ES&C, Inc.	G	
Herman N. Johnson, Jr.	Pike Energy Solutions	G	
David J. Marne	Marne and Associates, Inc.	G	
Percy E. Pool	Verizon	3	9
Keith Reese	Georgia Power Company	G	
Ewell T. Robeson	Duke Energy	3	9
Wade Shultz	Alabama Power Company	G	
Lawrence M. Slavin	Outside Plant Consulting Services, Inc.	G	
Lanny L. Smith	Consultant	G	
James R. Tomaseski	PAR Electrical Contractors, Inc.	G	

Key:
G = General (all areas); 1 = Part 1; 2 = Part 2; 3 = Part 3; 4 = Part 4; 9 = Section 9

Grounding
When a member has Section 9 and a part number, the member covers grounding and grounding for that part.

Procedure for revising the NESC

1. Preparation of proposals for amendment

   NOTE: The procedures for the collection of change proposals are subject to change for the 2022 NESC revision cycle. See http://standards.ieee.org/about/nesc/general.html for updates.

   1.1 A proposal may be prepared by any

   a. Substantially interested person

   b. Interested organization

   c. NESC Subcommittee

   d. Member of the NESC Committee or its subcommittees

   1.2 Change proposals shall be submitted to the Secretary of the National Electrical Safety Code Committee via the NESC's electronic revision process found at http://standards.ieee.org/about/nesc/index.html.

   1.3 Each separate topic shall begin on a separate form and shall only address one rule, unless a change in a rule directly affects another rule. If a proposal references documents not readily available to all subcommittee members, sufficient copies of the referenced documents to supply the subcommittee must be furnished.

   1.4 The proposal shall consist of

   a. A statement, in NESC rule form, of the exact change, rewording, or new material proposed.

   b. Words to be deleted shall be indicated via strikethroughs, and words to be added shall be underlined.

   c. The name of the submitter (organization or individual as applicable).

   d. Supporting comments, giving the reasons why the NESC should be revised.

   NOTE: A change proposal will not be accepted if these steps are not followed.

2. The NESC Secretary will

   a. Acknowledge receipt of proposals for revision.

   b. Distribute to each member of the appropriate NESC Subcommittee all of the proposals received, arranged in a coordinated sequence.

3. Subcommittee recommendation

   The NESC Subcommittee responsible will consider each proposal and take one or more of the following steps:

   a. Endorse the proposal as received.

   b. Prepare a proposed revision or addition for the NESC (this may be a coordination of several comments or a committee consensus on a modification of a proposal).

   c. Refer the proposal to a technical working group for detailed consideration.

   d. Request coordination with other NESC Subcommittees.

   e. Recommend rejection of the proposal, for stated reasons.

   For each item, the responsible subcommittee shall prepare a voting statement, accompanied by all members' statements concerning their votes (cogent reasons are required for negative votes). Steps (c) and (d) are intended to result, eventually, in a proposal of category (b).

Action under steps (c) or (d) shall be completed and reported to the subcommittee before the end of the public review period if the item is to be included in the upcoming revision.

4. Preprint of proposals

The NESC Secretary shall organize and publish a preprint of the proposed revisions including

a. The original proposal as received from the submitter.

b. The recommendation of the subcommittee with respect to the proposal (including a voting statement and subcommittee members' statements).

c. Copies of submittal form for comments.

The Preprint shall be distributed to all members of NESC Subcommittees and representatives of organizations comprising the NESC Committee. Copies shall be available for sale to other interested parties. Notice of availability of the Preprint shall be submitted to ANSI for publication in ANSI Standards Action. The Preprint shall carry information on how to submit comments on the proposals and the final date for such submissions.

5. Final processing of proposed revisions and comments

5.1 Following the public review period, the Secretary shall organize and distribute for subcommittee consideration all comments received electronically.

5.2 The Preprint and the comments received shall be reconsidered by the subcommittees. No new change proposals may be considered.

a. The subcommittee may recommend adoption or rejection of the proposal by majority vote.

b. When extended technical consideration or resolution of differing or conflicting points of view is necessary, the subcommittee shall refer the problem to a working group of the subcommittee for proposed resolution. If expeditious resolution is not possible, the subject shall be held on the docket.

Each working group shall provide, to its parent subcommittee, recommendations on matters considered as a result of subcommittee referrals under items 3(c) and 4.2(b).

Each subcommittee shall prepare a report showing its proposed revisions and all items held on the docket together with a plan for their disposition.

5.3 The Secretary shall provide commenters with copies of actions taken on the rules affected by their comments, and shall make all such reports available for examination upon request.

6. Final approval

6.1 Based upon the subcommittee reports, the Secretary shall prepare a draft of the revision of the NESC and distribute copies to

a. The NESC Committee for approval by a 30-day letter ballot

b. The ANSI Board of Standards Review for concurrent 45-day public review

Comments received in response to the letter ballot and public review shall be referred to the Executive Subcommittee for resolution or referral to the appropriate subcommittee. Those items on which consensus cannot be reached shall be referred to the appropriate subcommittee for consideration during the next revision cycle. Unless a consensus for revision is established, the requirements of the current edition shall carry over to the proposed edition.

Time schedule for the next revision of the NESC

The revision schedule for the 2022 NESC is as follows:

15 July 2018	Final date to receive change proposals from the public for revision of the 2017 Edition of the NESC, preparatory to the publication of a 2022 Edition.
September–October 2018	NESC Subcommittees consider change proposals to the NESC and prepare their recommendations.
1 September 2019	Preprint of the change proposals for incorporation into the 2022 Edition of the NESC published for distribution to the NESC Committee and other interested parties. This opens the comment period, by interested parties, on the submitted change proposals and the subcommittee recommendations.
1 May 2020	The final date to submit comments on the submitted change proposal and the subcommittee recommendations. All comments and recommendations on these proposals are due to the Secretary, NESC Committee.
September–October 2020	Period for NESC Subcommittee Working Groups and NESC Subcommittees to reconsider all recommendations concerning the proposed amendments and prepare a final report.
15 January 2021	Proposed revision of the NESC, Accredited Standards Committee C2, submitted to NESC Committee for letter ballot and to ANSI for concurrent public review.
15 May 2021	NESC Committee approved revisions of the NESC submitted to ANSI for recognition as an ANSI standard.
1 August 2021	Publication of the 2022 Edition of the NESC.

Working Group assignments and activities for the 2022 Edition

Subcommittee 2, Grounding Methods (SC2)

Working Group 2.1

A Task Force was formed to review CP4059 for possible requirements for grounding line side for services greater than 750 V.

Members: John Dagenhart, Keith Reese

Working Group 2.2

A Task Force was formed to review CP4058 to look at the diameter of different ground rods and modern materials and techniques.

Chair: Roger J. Montambo

Members: Trevor Bowmer, John Dagenhart, Keith Reese, Ewell T. Robeson

Subcommittee 3, Electric Supply Stations (SC3)

See NESC Subcommittee 8, WG 8.15 (following).

Subcommittee 4, Overhead Lines—Clearances (SC4)

Working Group 4.3

SC4 formed WG 4.3 to address all rules and tables for Rule 232 water crossing and to clarify the definition of "bodies and levels of water" (e.g., high water mark, flood level).

Chair: Douglas Proctor

Members: David D'Hooge, Alan Kuipers, Joseph L. White

Working Group 4.4

SC4 formed WG 4.4 to review the clearances between energized parts and down guys. Table 235-6, Row 2, a, b, c.

Chair: Branch Davis

Members: David D'Hooge, Mickey B. Gunter, Jeffery Hall, Douglas Proctor, Jeffrey Steiner

Subcommittee 5, Overhead Lines—Strength and Loading (SC5)

Working Group 5.1

Coordination of loading calculations in Sections 24, 25, and 26

WG 5.1/Task Force 5.1.3: Inconsistencies, clarifications, and modifications of Sections 24, 25, and 26.

WG 5.1/Task Force 5.1.5: Review/update, as required, the extreme wind methodology.

WG 5.1/Task Force 5.1.11: Eliminate the conductor constant (k factor).

Subcommittee 8—Work Rules (SC8)

Working Group 8.14

Work Group 8.14 was formed to address possible gaps in Part 4 rules applicable in generating stations.

Working Group 8.15

SC8 formed a working group to address remaining concerns regarding CP4176 and Rule 420G, Liquid-cell batteries. New working group may include SC3 members.

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Letter symbols for units

This Code uses standard symbols for units. They have the following meanings:

A	ampere
C	degree Celsius
ft	foot
ft^2	square foot
ft^3	cubic foot
F	degree Fahrenheit
g	gram
Hz	hertz
h	hour
in	inch
in^2	square inch
k	kilo (10^3)
kg	kilogram
kPa	kilopascal
km^2	square kilometer
kV	kilovolt (1000 V)
kVA	kilovoltampere
kW	kilowatt
m	meter
m^2	square meter
m^3	cubic meter
m	milli (10^{-3})
mA	milliampere
mi	mile (international)
mm	millimeter
min	minute (time)
N	newton
Pa	pascal
lb	pound
s	second (time)
V	volt
W	watt

Section 1.
Introduction to the
National Electrical Safety Code®

The National Electrical Safety Code (NESC®) is American National Standard C2. It is a consensus standard that has been prepared by the National Electrical Safety Code Committee under procedures approved by the American National Standards Institute (ANSI). The membership of the NESC Committee is composed of national and international organizations and is certified by ANSI as having an appropriate balance of the interests of members of the public, utility workers, regulatory agencies, and the various types of private and public utilities.

The NESC is used in whole or in part by statute, regulation, or consent as the standard (or basis of the standard) of safe practice for public and private utilities in the United States, as well various jurisdictions and industries in other countries.

010. Purpose

A. The purpose of the NESC is the practical safeguarding of persons and utility facilities during the installation, operation, and maintenance of electric supply and communication facilities, under specified conditions.

   NOTE: NESC rules are globally recognized and intended to provide a practical standard of safe practices that can be adopted by public utilities, private utilities, state or local utility commissions or public service commissions, or other boards or bodies having control over safe practices employed in the design, installation, operation, and maintenance of electric supply, communication, street and area lighting, signal, or railroad utility facilities.

B. NESC rules contain the basic provisions, under specified conditions, that are considered necessary for the safeguarding of:

   1. The public,
   2. Utility workers (employees and contractors), and
   3. Utility facilities.

C. This Code is not intended as a design specification or as an instruction manual.

011. Scope

A. Covered

   See Figure 011-1.

   The NESC covers:

   1. Supply and communication facilities (including metering) and associated work practices employed by a public or private electric supply, communications, railway, trolley, street and area lighting, traffic signal (or other signal), irrigation district or other community owned utility, or a similar utility in the exercise of its function as a utility.
   2. The generation, transmission, and distribution of electricity, lumens, communication signals, and communication data through public and private utility systems that are installed and maintained under the exclusive control of utilities or their authorized representatives.
   3. Utility facilities and functions of utilities that either (a) generate energy by conversion from some other form of energy such as, but not limited to, fossil fuel, chemical, nuclear, solar, mechanical, wind or hydraulic or communication signals, or accept energy or communication signals from another entity, or (b) provide that energy or communication signals through a delivery point to another entity.

4. Street and area lights that provide a supply of lumens where these facilities are supplied from the line side of the service point by underground or overhead conductors maintained and/or installed under the exclusive control of utilities (including their authorized contractors or other qualified persons).
5. Utility facilities and functions on the line side of the service point supplied by underground or overhead conductors installed and/or maintained under exclusive control of utilities located on public or private property in accordance with legally established easements or rights-of-way, contracts, other agreements (written or by conditions of service), or as authorized by a regulating or controlling body.

   NOTE: Agreements to locate utility facilities on property may be required where easements are either (a) not obtainable (such as locating utility facilities on existing rights-of-way of railroads or other entities, military bases, federal lands, Native American reservations, lands controlled by a port authority, or other governmental agency), or (b) not necessary (such as locating facilities necessary for requested service to a site).
6. Wiring within a supply station or in an underground facility that is (a) installed in accordance with Part 1 or Part 3 of this Code and maintained under the exclusive control of utilities and (b) necessary for the operation of the supply station or underground facility.
7. Utility facilities installed, maintained, and controlled by utilities on surface or underground mine sites, including overhead or underground distribution systems providing service up to buildings or outdoor equipment locations on the line side of the service point.
8. Similar systems to those listed above that are under the exclusive control of qualified persons and authorized by a regulating or controlling body, including those associated with an industrial complex or utility interactive system.

B. Not covered

See Figure 011-1.

NESC rules do not cover:

1. Utilization equipment or premises wiring located beyond utility service points to buildings or outdoor installations, or
2. Underground mine wiring or installations in ships, railway rolling equipment, aircraft, or automotive equipment, or
3. Luminaires not installed or maintained under exclusive control by utilities, or
4. Industrial complex or utility interactive systems that are not controlled exclusively under utilities or qualified persons or are located on the premises wiring side of the service point.

   NOTE: The National Electrical Code® (NEC®) (NFPA 70®, 2011 Edition) covers utilization wiring requirements beyond the service point and luminaires that are not controlled exclusively by utilities.[1]

[1] Information on references can be found in Section 3.

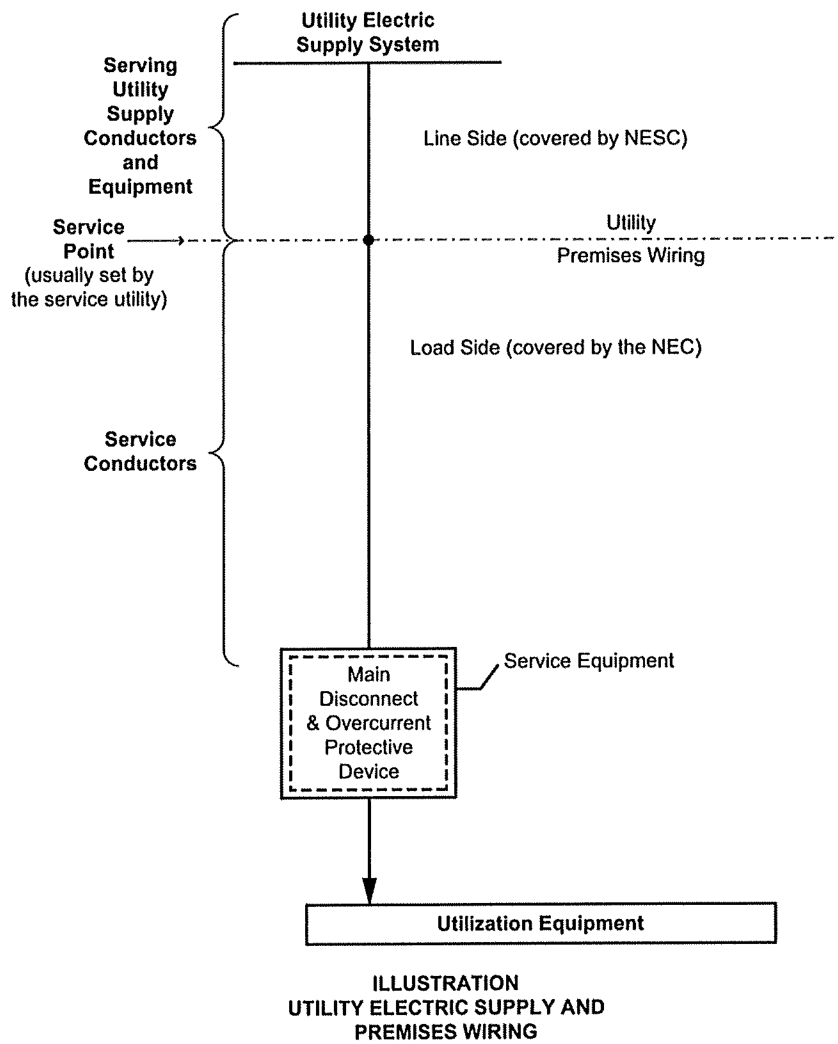

Figure 011-1—Service point—General illustration of what is covered and not covered by the NESC

C. Types of requirements

1. These rules specify:

   a. Loadings and factors related to required strength of utility structures and supported facilities;

   b. Clearances and spacings between: (1) facilities of different utilities, (2) facilities of same utility, and (3) utility facilities and public facilities;

   c. Grounding; and

   d. Other requirements related to the safeguarding of persons and facilities, including associated safe work practices, to be employed by a utility in the exercise of its function as a utility up to the service point.

2. Utilities operating under the NESC are required to maintain control over the system up to the service point such that:

   a. The system is designed to meet the requirements of specified conditions, and

b. The personnel installing, maintaining, and operating the system and its components are qualified to do so, are adequately supervised, use appropriate tools, and follow safe work procedures.

012. General rules

A. All electric supply and communication lines and equipment shall be designed, constructed, operated, and maintained to meet the requirements of these rules.

B. The utilities, authorized contractors, or other entities, as applicable, performing design, construction, operation, or maintenance tasks for electric supply or communication lines or equipment covered by this Code shall be responsible for meeting applicable requirements.

C. For all particulars not specified, but within the scope of these rules, as stated in Rule 011A, construction and maintenance should be done in accordance with accepted good practice for the given local conditions known at the time by those responsible for the construction or maintenance of the communication or supply lines and equipment.

013. Application

A. New installations and extensions

1. These rules shall apply to all new installations and extensions, except that they may be waived or modified by the administrative authority. When so waived or modified, safety shall be provided in other ways.

   EXAMPLE: Alternative working methods, such as the use of barricades, guards, or other electrical protective equipment, may be implemented along with appropriate alternative working clearances as a means of providing safety when working near energized conductors.

2. Types of construction and methods of installation other than those specified in the rules may be used experimentally to obtain information if:

   a. Qualified supervision is provided,

   b. Equivalent safety is provided, and

   c. On joint-use facilities, all affected joint users are notified in a timely manner.

B. Existing installations

1. Where an existing installation meets, or is altered to meet, these rules, such installation is considered to be in compliance with this edition and is not required to comply with any previous edition.

2. Existing installations, including maintenance replacements, that currently comply with prior editions of the Code, need not be modified to comply with these rules.

   EXCEPTION 1: For safety reasons, the administrative authority may require compliance with these rules.

   EXCEPTION 2: When a structure is replaced, the current requirements of Rule 238C shall be met, if applicable.

3. Where conductors or equipment are added, altered, or replaced on an existing structure, the structure or the facilities on the structure need not be modified or replaced if the resulting installation will be in compliance with either (a) the rules that were in effect at the time of the original installation, or (b) the rules in effect in a subsequent edition to which the installation has been previously brought into compliance, or (c) the rules of this edition in accordance with Rule 013B1. When an existing installation is brought into compliance with a subsequent edition, earlier editions no longer apply.

4. For structures that currently do not comply with Rule 013B3, if adding a new item, or replacing or rearranging existing items would not in itself, either (1) create a structural, clearance, or grounding non-conformance, or (2) worsen an existing non-conformance, then the addition, replacement, or alteration may be performed prior to correcting existing non-compliance items. For existing non-compliance items, see Rules 214A4 and A5.

C. Inspection and work rules

Inspection rules and work rules in the current edition of the NESC shall apply to inspection of or work on all new and existing installations.

014. Waiver for emergency and temporary installations

The person responsible for an installation may modify or waive rules in the case of emergency or temporary installations.

A. Emergency installations

1. The clearances required in Section 23 may be decreased for emergency installations. See Rule 230A.
2. The burial depth requirements in Part 3 may be waived for the duration of the emergency. See Rule 311C.
3. The strength of material and construction for emergency installations shall be not less than that required for Grade N construction. See Rule 263.
4. Emergency installations shall be removed, replaced, or relocated, as desired, as soon as practical.

B. Temporary overhead installations

When an installation is temporary, or where facilities are temporarily relocated to facilitate other work, the installation shall meet the requirements for non-temporary installation except that the strength of material and construction shall be not less than that required for Grade N construction. See Rule 263.

015. Intent

A. The word *shall* indicates provisions that are mandatory.

B. The word *should* indicates provisions that are normally and generally practical for the specified conditions. However, where the word "should" is used, it is recognized that, in certain instances, additional local conditions not specified herein may make these provisions impractical. When this occurs, the difference in conditions shall be appropriately recognized and Rule 12 shall be met.

C. Footnotes to a table are designated by a circle surrounding the footnote number. Footnotes to a table have the same force and effect that is required or allowed by the rule that specifies the use of the table.

D. The word *"EXCEPTION"* indicates a specified option that may be substituted for one or more of the requirements stated in the rule or table, at the option of the utility. *EXCEPTIONS* to a rule have the same force and effect that is required or allowed by the rule to which the *EXCEPTION* applies.

NOTE: EXCEPTIONS recognize alternatives to generally applied requirements that are safe under the specified conditions. In some cases, an *EXCEPTION* may merely be a less frequently used safe option that may be preferable under the particular constraints of the site or work.

E. The word *"RECOMMENDATION"* indicates provisions considered desirable, but that are not intended to be mandatory.

F. The word *"NOTE"* or the word *"EXAMPLE"* used in a rule indicates material provided for information or illustrative purposes only. *NOTES* and *EXAMPLES* are not mandatory and are not considered to be a part of Code requirements.

G. A *RECOMMENDATION, EXCEPTION,* or *NOTE* applies to all text in that rule above its location that is indented to the same level.

016. Effective date

This edition may be used at any time on or after the publication date. Additionally, this edition shall become effective no later than the first day of the month after 180 days have elapsed following its publication date for application to new installations and extensions where both design and approval were started after the expiration of that period, unless otherwise stipulated by the administrative authority. *Example*: If the NESC is published on August 1, 2016, then it will become effective on February 1, 2017.

NOTE: A period of not less than 180 days is allowed for utilities and regulatory authorities to acquire copies of the new edition and to change regulations, internal standards, and procedures as may be required. There is neither an intention to require or imply that this edition be implemented before 180 days from the publication date, nor an intention to prohibit earlier implementation.

017. Units of measure

A. Numerical values in the requirements of this Code are stated in the metric system and in the customary inch-foot-pound system. In text, the metric value is shown first with the customary inch-foot-pound (inside parentheses) following. Extensive detailed tables are duplicated. The first, marked **m**, contains metric (SI) values; the second, marked **in**, **ft**, or **lb**, contains the inch-foot-pound values. Tensions and wind loads are stated in newtons, the SI unit of force.

The SI values and the customary inch-foot-pound values are not, nor are they intended to be, identical measures. The values shown in each system of measurement have been rounded to convenient numbers in order to simplify measurement and to minimize errors. The values shown in each system are functional equivalents for safety purposes.

The values required in this Code have been carefully developed and evaluated to ensure that the intended levels of safety are provided in both systems; neither is distinguishable from the other for safety purposes. The values specified in either system of measurement may be used, or the values of the two systems may be intermixed, as desired.

NOTE 1: Le Système Internationale d'Unités (The International System of Units [or SI] in the modern version of the metric system). For basic information and conversion factors, see IEEE/ASTM SI 10™-2010 [B31].[2]

NOTE 2: It is recognized that many equivalent utility system components may be purchased in both SI and customary units.

B. Unless dimensions are specifically stated in this Code, the dimensions of physical items referenced in this Code, such as wires, are "nominal values" assigned for the purpose of convenient designation. Due to manufacturing limitations or other restraints, other standards may set tolerances, variations, or ranges for the dimensions of such items.

018. Method of calculation

Where calculations are required by these rules, the resultant value shall be rounded off to the nearest significant digit, unless otherwise specified in the applicable rule(s).

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[2]The numbers in brackets correspond to those of the bibliography in Appendix E.

Section 2.
Definitions of special terms

The following definitions are for use with the National Electrical Safety Code. For other use, and for definitions not contained herein, the *IEEE Standards Dictionary Online* should be referenced.

NOTE: IEEE Standards Dictionary Online is available at: http://ieeexplore.ieee.org/xpls/dictionary.jsp.

administrative authority. The governmental authority exercising jurisdiction over application of this Code.

ampacity. The current-carrying capacity, expressed in amperes, of an electric conductor under stated thermal conditions.

anchorage. A secure point of attachment to which the fall protection system is connected.

area lighting. An electrical installation that provides lumens on public or private property.

NOTE: Area lighting installations under the exclusive control of a utility are covered by the NESC. All other area lighting installations are covered by the NEC.

authorized person. A person who has been authorized by the controlling utility or its designated representative to perform specified duties in, on, or in the vicinity of utility facilities, as applicable.

automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence—as, for example, a change in current strength; not manual; without personal intervention. Remote control that requires personal intervention is not automatic, but manual.

backfill (noun). Materials such as sand, crushed stone, or soil, that are placed to fill an excavation.

ballast section (railroads). The section of material, generally trap rock, that provides support under railroad tracks.

bonding. The electrical interconnecting of conductive parts, designed to maintain a common electrical potential.

cable. A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

cable jacket. A protective covering over the insulation, core, or sheath of a cable.

cable sheath. A conductive protective covering applied to cables.

NOTE: A cable sheath may consist of multiple layers, of which one or more is conductive.

cable terminal. A device that provides insulated egress for the conductors. *Syn:* **termination.**

circuit. A conductor or system of conductors through which an electric current is intended to flow.

circuit breaker. A switching device capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal conditions such as those of short circuit.

clearance. The clear distance between two objects measured surface to surface, and usually filled with a gas such as air.

climbing. The vertical movement (ascending and descending) and horizontal movement to access or depart the worksite.

common use. Simultaneous use by two or more utilities of the same kind.

communication equipment. Equipment that produces, modifies, regulates, or controls communication signals. This equipment may also produce, modify, or safeguard a supply of electric energy for the exclusive use of communication devices as long as the equipment and communication devices being served are owned and operated by the same party. *See:* **electric supply equipment**.

communication lines. *See:* **lines.**

communication space. The space on joint-use structures where communication facilities are separated from the supply space by the communication worker safety zone. See Figure D-1.

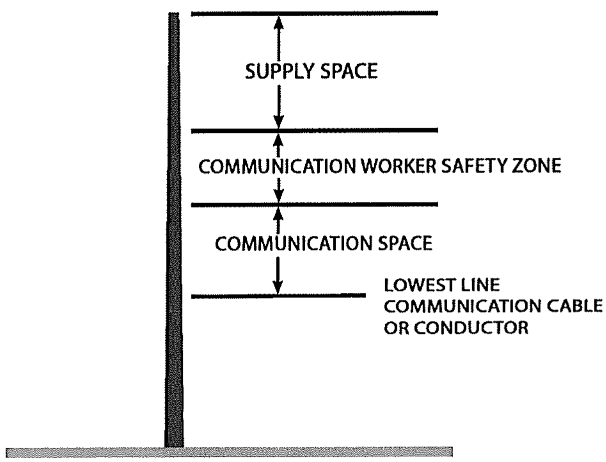


Figure D-1—Communication space

conductor.

1. A material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current.
2. **bare conductor.** A metallic conductor without a covering.
3. **bundled conductor.** An assembly of two or more conductors used as a single conductor and employing spacers to maintain a predetermined configuration. The individual conductors of this assembly are called *subconductors*.
4. **covered conductor.** A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.
5. **fiber-optic conductor.** *See:* **fiber-optic cable—communication** or **fiber-optic cable—supply.**
6. **grounded conductor.** A conductor that is intentionally grounded, either solidly or through a noninterrupting current-limiting device.
7. **grounding conductor.** A conductor that is used to connect the equipment or the wiring system with a grounding electrode or electrodes.
8. **insulated conductor.** A conductor covered with a dielectric (other than air) having a rated insulating strength equal to or greater than the voltage of the circuit in which it is used.
9. **lateral conductor.** A wire or cable entirely supported on one structure and extending in a general horizontal, vertical, or diagonal direction to make connections to line conductors, service drops, equipment, or other facilities supported on the same structure. Lateral conductors may be attached directly to the structure or supported away from the structure.

10. **line conductor.** (Overhead supply or communication lines.) A wire or cable intended to carry electric currents, extending along the route of the line, supported by poles, towers, or other structures, but not including vertical or lateral conductors.
11. **open conductor.** A type of electric supply or communication line construction in which the conductors are (a) bare, covered, or insulated, (b) do not have grounded shielding, and (c) are individually supported at the structure either directly or with insulators. *Syn:* **open wire.**
12. **vertical conductor.** Either a wire or cable riser attached to a pole or a vertical portion of a lateral conductor.

conductor shielding. An envelope that encloses the conductor of a cable and provides an equipotential surface in contact with the cable insulation.

conduit. A structure containing one or more ducts.

NOTE: Conduit may be designated as iron-pipe conduit, tile conduit, etc. If it contains only one duct, it is called *single-duct conduit;* if it contains more than one duct, it is called *multiple-duct conduit,* usually with the number of ducts as a prefix, e.g., *two-duct multiple conduit.*

conduit system. Any combination of duct, conduit, conduits, manholes, handholes, and/or vaults joined to form an integrated whole.

current-carrying part. A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

de-energized. Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means.

NOTE: De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

delivery point. The point at which one utility delivers energy or signals to another utility.

designated person. A qualified person designated to perform specific duties under the conditions existing. *Syn:* **designated employee.**

disconnecting or isolating switch. A mechanical switching device used for changing the connections in a circuit or for isolating a circuit or equipment from a source of power.

NOTE: It is required to carry normal load current continuously as well as abnormal or short-circuit current for short intervals, as specified. It is also required to open or close circuits either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the switch poles occurs. *Syn:* **disconnector, isolator.**

duct. A single enclosed raceway for conductors or cable.

effective ground/effectively grounded: Bonded to an effectively grounded neutral conductor or to a grounding system designed to minimize hazard to personnel and having resistances to ground low enough to permit prompt operation of circuit protective devices.

effectively grounded neutral conductor: A conductor that is intentionally connected to the source transformer neutral directly or through an impedance to limit phase-to-ground fault current and has not less than four grounds in each 1.6 km (1.0 mi) of line. The conductor shall be of sufficient size to carry the available fault current and permit prompt operation of circuit protective devices.

electric supply equipment. Equipment that produces, modifies, regulates, controls, or safeguards a supply of electric energy for the electric power supply grid that is (1) transferred to supply lines, or (2) used to provide power and/or control for other electric supply equipment, or (3) used to provide power to the devices of another utility. *Syn:* **supply equipment.**

> NOTE: *Electric supply equipment* does not include equipment whose purpose is to provide power to support locally mounted communication systems. For example, power supplies supporting CATV or communication amplifiers or repeaters are not considered to be supply equipment.

electric supply lines. *See:* **lines.**

electric supply station. Any building, room, or separate space within which electric supply equipment is located and the interior of which is accessible, as a rule, only to qualified persons. This includes generating stations and substations, including their associated generator, storage battery, transformer, and switchgear rooms or enclosures, but does not include facilities such as pad-mounted equipment and installations in manholes and vaults.

1. **generating station.** A plant wherein electric energy is produced by conversion from some other form of energy (e.g., fossil fuel, chemical, nuclear, solar, mechanical, wind, or hydraulic) by means of suitable apparatus. This includes all generating station auxiliaries and other associated equipment required for the operation of the plant. Not included are stations producing power exclusively for use with communications systems.
2. **substation.** An enclosed assemblage of equipment, e.g., switches, circuit breakers, buses, and transformers, under the control of qualified persons, through which electric energy is passed for the purpose of switching or modifying its characteristics to increase or decrease voltage or control frequency or other characteristics.
3. **switching station.** *See:* **substation.**

enclosed. Surrounded by case, cage, or fence designed to protect the contained equipment and limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects.

energized. Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity. *Syn:* **live.**

equipment. A general term including fittings, devices, appliances, fixtures, apparatus, and similar terms used as part of or in connection with an electric supply or communications system.

exclusive control. Generally covers installation, ownership, restricted access, operation, and maintenance by qualified and authorized persons.

exclusive control of utility. Where (a) energized facilities are separated from public access by a spatial or a physical barrier and accessible only to qualified personnel authorized by the serving utility, and (b) the utility is responsible for connection/disconnection of such facilities to/from energized sources of energy or signals.

exposed. Not isolated or guarded.

fall arrest system. The assemblage of equipment, such as a line-worker's body belt, aerial belt, or full body harness in conjunction with a connecting means, with or without an energy absorbing device, and an anchorage to limit the forces a worker can experience during a fall.

fall prevention system. A system, which may include a positioning device system, intended to prevent a worker from falling from an elevation.

fall protection program. A program intended to protect workers from injury due to falls from elevations.

fall protection system (hardware). Consists of either a fall prevention system or a fall arrest system.

fiber-optic cable—communication. A fiber-optic cable meeting the requirements for a communication line and located in the communication space of overhead or underground facilities.

fiber-optic cable—supply. A fiber-optic cable located in the supply space of overhead or underground facilities.

grounded. Connected to or in contact with earth or connected to some extended conductive body that serves instead of the earth.

grounded effectively. *See:* **effective ground/effectively grounded.**

grounded system. A system of conductors in which at least one conductor or point is intentionally grounded, either solidly or through a noninterrupting current-limiting device.

guarded. Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats or platforms, designed to limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects.

> *NOTE:* Wires that are insulated but not otherwise protected are not normally considered to be guarded. See *EXCEPTIONS* under applicable rules.

handhole. An access opening, provided in equipment or in a below-the-surface enclosure in connection with underground lines, into which personnel reach but do not enter, for the purpose of installing, operating, or maintaining equipment or cable or both.

harness. A component with a design of straps that is fastened about the worker in a manner so as to contain the torso and distribute the fall arrest forces over at least the upper thighs, pelvis, chest, and shoulders with means for attaching it to other components and subsystems.

> *NOTE:* Wherever the word *harness* is used in this Code, it refers to *full body harness.*

in service. Lines and equipment are considered in service when connected to the system and intended to be capable of delivering energy or communication signals, regardless of whether electric loads or signaling apparatus are presently being served from such facilities.

insulated. Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

> *NOTE:* When any object is said to be *insulated,* it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is, within the purpose of these rules, uninsulated.

insulation (as applied to cable). That which is relied upon to insulate the conductor from other conductors or conducting parts or from ground.

insulation shielding. An envelope that encloses the insulation of a cable and provides an equipotential surface in contact with the cable insulation.

insulator. Non-conductive device designed to provide mechanical connection and electrical separation between objects.

> *NOTE:* Examples include but are not limited to pin, post, or suspension insulators supporting conductors; electrical bus support insulators; and guy strain insulators.

isolated. Not readily accessible to persons unless special means for access are used.

isolated by elevation. Elevated sufficiently so that persons may safely walk underneath.

isolator. *See:* **disconnecting or isolating switch.**

jacket. A protective covering over the insulation, core, or sheath of a cable.

joint use. Simultaneous use by two or more utilities.

lanyard. A flexible line or webbing, rope, wire rope, or strap that generally has a connector at each end for connecting the line-worker's body belt, aerial belt, or full body harness to an energy absorbing device, lifeline, or anchorage.

lightning arrester. *See:* **surge arrester.**

limited access highways. As used herein, *limited access highways* are fully controlled highways where access is controlled by a governmental authority or a private toll road operator for purposes of improving traffic flow and safety. Fully controlled access highways have no grade crossings and have carefully designed access connections.

lines.

1. **communication lines.**
   a. **located in the communication space.** The conductors and their supporting or containing structures, equipment, and apparatus that are used for public or private signal or communications service, and which operate at potentials not exceeding 400 V to ground or 750 V between any two points of the circuit, and the transmitted power of which does not exceed 150 W. When operating at not more than 90 V ac or 150 V dc, no limit is placed on the transmitted power of the system. Under specified conditions, communication cables may include communication circuits exceeding the preceding limitation where such circuits are also used to supply power solely to communications equipment. Fiber-optic cables are considered as communication lines, regardless of whether they are installed in the communication space or supply space in accordance with applicable rules,

      NOTE: Public and private telephone, telegraph, railroad-signal, data, clock, fire, police-alarm, cable-television, and other systems conforming with the above are included. Lines used for signaling purposes, but not included under the above definition, are considered as supply lines of the same voltage and are to be so installed. Traffic signal light lines are considered as supply lines, not communication lines.

   b. **located in the supply space.** Communication lines located in the supply space and meeting Rule 224A may (a) operate at any voltage, (b) include supply circuits of any voltage, or (c) be included within a supply conductor or cable operating at any voltage.

2. **electric supply lines.** Those wires, conductors, and cables used to transmit electric or light energy and their necessary supporting or containing structures, equipment, and apparatus that are used to provide public or private electric supply or lighting service.

   Signal lines of more than 400 V and traffic signal lines of any voltage are always considered as supply lines within the meaning of the rules, and signal lines of less than 400 V may be considered as supply lines, if so run and operated throughout.

   Although fiber-optic lines are considered as communication lines, regardless of whether they are installed in the communication space or supply space in accordance with applicable rules, electric supply conductors to light amplifiers, etc., are considered as supply lines, unless contained within a communication cable in accordance with the definition of communication lines and applicable rules. *Syn:* **supply lines.**

3. **joint-use lines.** Overhead or underground lines containing or supporting facilities of two or more utilities. Lines containing or supporting facilities delivering two or more types of service by the same owner, such as electricity and lighting supply service or telephone and CATV communication service, are not considered as joint-use lines, unless also accompanied by one or more lines of another utility.

line-worker's body belt. A belt that consists of a belt strap and D-rings and which may include a cushion section or a tool saddle.

live. *See:* **energized.**

manhole. A subsurface enclosure that personnel may enter used for the purpose of installing, operating, and maintaining submersible equipment and cable.

manhole cover. A removable lid that closes the opening to a manhole or similar subsurface enclosure.

manhole grating. A grid that provides ventilation and a protective cover for a manhole opening.

manual. Capable of being operated by personal intervention.

minimum approach distance. The closest distance a qualified employee is permitted to approach either an energized or a grounded object, as applicable for the work method being used.

multigrounded/multiple grounded system. A system of conductors in which a neutral conductor is intentionally grounded solidly at specified intervals. A multigrounded or multiple grounded system may or may not be effectively grounded. *See:* **effective ground/effectively grounded.**

neutral conductor. A system conductor other than a phase conductor that provides a return path for current to the source. Not all systems have a neutral conductor. An example is an ungrounded delta system containing only three energized phase conductors.

out of service. Lines and equipment are considered out of service when disconnected from the system and when not intended to be capable of delivering energy or communications signals.

overhead ground wire. *See:* **shield wire.**

overvoltage. Voltage between two points of a system that is greater than the highest value appearing between the same two points under normal service conditions. Overvoltages include, but are not limited to, switching impulse (switching surge) overvoltages and temporary (transient) overvoltages.

pad-mounted equipment. A general term describing enclosed equipment, the exterior of which enclosure is at ground potential, positioned on a surface-mounted pad.

positioning device system. A system of equipment or hardware that, when used with its line-worker's body belt or full body harness, allows a worker to be supported on an elevated vertical surface, such as a pole or tower, and work with both hands free.

positioning strap. A strap with snap hook(s) to connect to the D-rings of a line-worker's body belt or full body harness.

premises. The land and buildings of a user located on the user side of the service point (sometimes called the *utility-user network point of demarcation* for communication wiring) to electric supply, communication, or signal premises wiring.

premises wiring (system). Interior and exterior wiring, including power, lighting, control, communication, and other signal circuit wiring together with all their associated hardware, fittings, and wiring devices, both permanently and temporarily installed either (a) from the service point or premises power source to the outlets, or (b) where there is no service point, from and including the non-utility power source to the outlets.

Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, motor control centers, and similar equipment, nor does it include utility equipment and wiring on the utility side of the service point.

prestressed-concrete structures. Concrete structures that include metal tendons that are tensioned and anchored either before or after curing of the concrete.

pulling iron. An anchor secured in the wall, ceiling, or floor of a manhole or vault to attach rigging used to pull cable.

pulling tension. The longitudinal force exerted on a cable during installation.

qualified. Having been trained in and having demonstrated adequate knowledge of the installation, construction, or operation of lines and equipment and the hazards involved, including identification of and exposure to electric supply and communication lines and equipment in or near the workplace. An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training, and who is under the direct supervision of a qualified person, is considered to be a qualified person for the performance of those duties.

qualified climber. A worker who, by reason of training and experience, understands the methods and has routinely demonstrated proficiency in climbing techniques and familiarity with the hazards associated with climbing.

raceway. Any channel designed expressly and used solely for holding conductors.

random separation. Installed with less than 300 mm (12 in) separation and without deliberate separation.

remotely operable (as applied to equipment). Capable of being operated from a position external to the structure in which it is installed or from a protected position within the structure.

restricted access. Where exclusive control is maintained.

roadway. The portion of highway, including shoulders, for vehicular use. *See also:* **shoulder**; **traveled way.**

NOTE: A divided highway has two or more roadways.

sag.

1. The distance measured vertically from a conductor to the straight line joining its two points of support. Unless otherwise stated in the rule, the sag referred to is the sag at the midpoint of the span. See Figure D-2.
2. **initial sag.** The sag of a conductor prior to the application of any external load.
3. **final sag.** The sag of a conductor under specified conditions of loading and temperature applied, after it has been subjected for an appreciable period to the loading specified for the clearance zone in which it is situated or equivalent loading, and this loading is then removed. Final sag includes the effect of inelastic deformation.

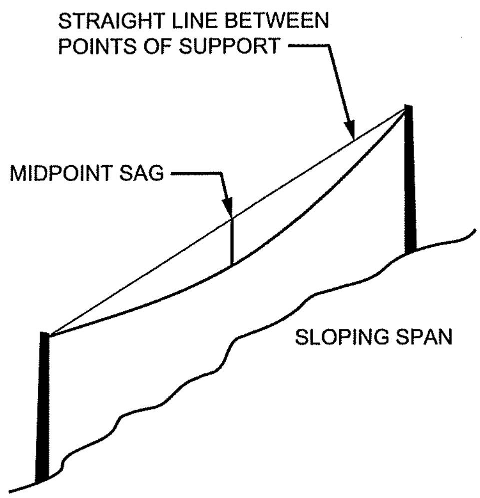


Figure D-2—Sag

separation. The distance between two objects, measured surface to surface, and usually filled with a solid or liquid material.

service drop. The overhead conductors between the electric supply or communication line and the building or structure being served.

service point. The point of connection between the facilities of the serving utility and the premises wiring.

> *NOTE:* The service point is the point of demarcation between the serving utility and the premises wiring. The service point is the point on the wiring system where the serving utility wiring ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the utility's condition of service.
>
> Because the location of the service point is generally determined by the utility, the service-drop conductors and the service-lateral conductors may or may not be part of the service covered by the NEC. For these types of conductors to be covered, they must be physically located on the premises wiring side of the service point. If the conductors are located on the utility side of the service point, they are not covered by the NEC definition of service conductors and are therefore not covered by the NEC.
>
> Based on the definitions of the terms *service point* and *service conductors,* any conductor on the serving utility side of the service point generally is not covered by the NEC. For example, a typical suburban residence has an overhead service drop from the utility pole to the house. If the utility specifies that the service point is at the point of attachment of the service drop to the house, the service-drop conductors are not considered service conductors because the service drop is not on the premises wiring side of the service point. Alternatively, if the utility specifies that the service point is "at the pole," and the service-drop conductors are not under utility control, the NEC would apply to the service drop.
>
> Exact locations for a service point may vary from utility to utility, as well as from occupancy to occupancy.

shield wire (also referred to as overhead ground wire, static wire, or surge-protection wire). A wire or wires, which may or may not be grounded, strung parallel to and above phase conductors to protect the power system from lightning strikes.

shoulder. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles for emergency use and for lateral support of base and surface course.

side-wall pressure. The crushing force exerted on a cable during installation.

single-grounded system/unigrounded system. A system of conductors in which one conductor is intentionally grounded solidly at a specific location, typically at the source.

spacer cable. A type of electric supply-line construction consisting of an assembly of one or more covered conductors, separated from each other and supported from a messenger by insulating spacers.

spacing. The distance between two objects measured center to center.

span.

1. **span length.** The horizontal distance between two adjacent supporting points of a conductor.
2. **wind span.** The sum of half of the span lengths on either side of the supporting structures. See Figure D-3.

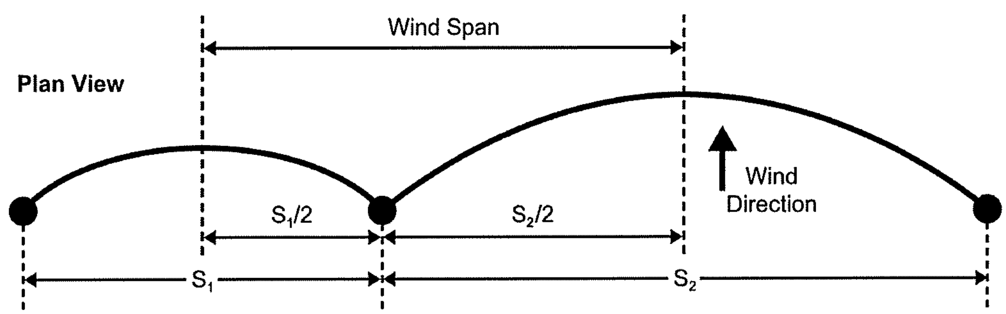
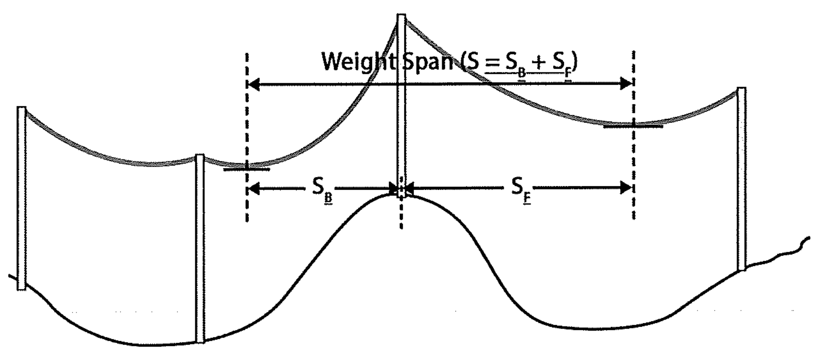


Figure D-3—Wind span

3. **weight span.** The sum of the horizontal distances from the supporting structure to the real or projected low point of conductor/cable sag in each supported span. See Figure D-4. *Syn:* **vertical span.**

   NOTE: Where the projected low point is beyond the adjacent structure, the weight span may exceed the actual span.



NOTE: Subscripts B and F stand for backspan and forespan, respectively.

Figure D-4—Weight span

span wire. An auxiliary suspension wire that serves to support one or more trolley contact conductors or a light fixture and the conductors that connect it to a supply system.

static wire. *See:* **shield wire.**

structure conflict. A line so situated with respect to a second line that the overturning of the first line will result in contact between its supporting structures or conductors and the conductors of the second line, assuming that no conductors are broken in either line.

substation. *See:* **electric supply station.**

supervised installation. Where conditions of maintenance and supervision ensure that only qualified persons monitor and service the system.

supply equipment. *See:* **electric supply equipment.**

supply space. The space on joint-use structures where supply facilities are separated from the communication space by the communication worker safety zone. See Figure D-5.

NOTE: Communication facilities may be located in the supply space (see Rule 224A).

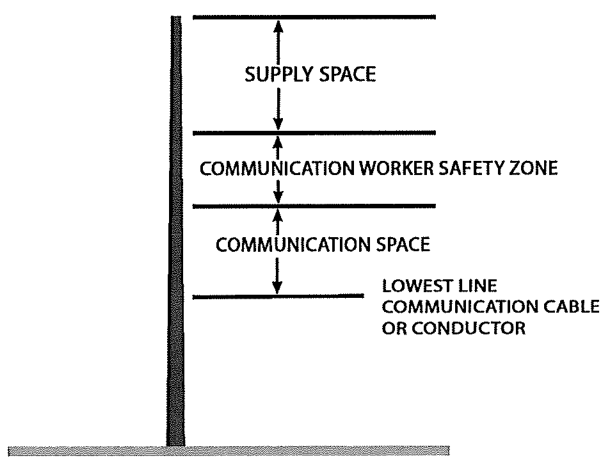


Figure D-5—Supply space

supply station. *See:* **electric supply station.**

supported facility. Any component of an overhead line system that is supported on, but is not intended to provide structural strength to, the supporting structure or mechanical support system.

NOTE: Examples of supported facilities include, but are not limited to, components such as messengers, conductors, line hardware, equipment hanger brackets, and switches.

supporting structure. The main supporting unit (usually a pole or tower) used to support supply and/or communication conductors, cables, and equipment.

NOTE: A supporting structure may consist of a single or multiple pole arrangement that supports supply and/or communication conductors, cables, and equipment at a line location.

1. **readily climbable.** A supporting structure having sufficient handholds or footholds so that the structure can be climbed easily by an average person without using a ladder, tools or devices, or extraordinary physical effort.

2. **not readily climbable.** A supporting structure not meeting the definition of a readily climbable structure, including but not limited to the following:

a. supporting structures, including poles and tower legs, with handholds or footholds arranged so that there is not less than 2.45 m (8 ft) between either: (1) the lowest handhold or foothold and ground or other accessible surface, or (2) the two lowest handholds or footholds. Diagonal braces on towers are not considered to be handholds or footholds except at their points of attachment.

b. guy wires

surge arrester. A protective device for limiting surge voltages.

surge-protection wire. *See:* **shield wire.**

susceptiveness. The characteristics of a communication circuit, including its connected apparatus, that determine the extent to which it is adversely affected by inductive fields.

switch. A device for opening and closing or for changing the connection of a circuit. In these rules, a switch is understood to be manually operable, unless otherwise stated.

switchboard. A type of switchgear assembly that consists of one or more panels with electric devices mounted thereon, and associated framework.

tag. Accident prevention tag (DANGER, PEOPLE AT WORK, etc.) of a distinctive appearance used for the purpose of personnel protection to indicate that the operation of the device to which it is attached is restricted.

tension

1. **initial.** The tension in a conductor prior to the application of any external load.
2. **final.** The tension in a conductor under specified conditions of loading and temperature applied, after it has been subjected for an appreciable period to the loading specified for the loading district (zone) in which it is situated, or equivalent loading, and this loading removed. Final tension includes the effect of inelastic deformation (creep).

termination. *See:* **cable terminal.**

transferring (as applied to fall protection). The act of moving from one distinct object to another (e.g., between an aerial device and a structure).

transformer vault. An isolated enclosure either above or below ground with fire-resistant walls, ceiling, and floor, in which transformers and related equipment are installed, and which is not continuously attended during operation. *See also:* **vault.**

transitioning (as applied to fall protection). The act of moving from one location to another on equipment or a structure.

traveled way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and full-time parking lanes.

ungrounded system. A system of conductors in which no conductor or point is intentionally grounded, either solidly or through a noninterrupting current-limiting device.

unigrounded system. *See:* **single-grounded system/unigrounded system.**

utility. An organization responsible for the engineering and supervision (design, construction, operation, and maintenance) of a public or private electric supply, communication, area lighting, street lighting, signal, or railroad utility system.

1. **public utility.** A public utility is an entity that performs or provides one or more utility services for the benefit of multiple customers (at retail, wholesale, or both), including utilities formed for a singular purpose (including but not limited to providing street and outdoor lighting, municipal traffic signal control, or distributed generation). Public utilities include investor-owned, municipality/government-owned, cooperative-owned utility, public utility districts, irrigation districts, lighting districts, traffic signal or other signal utilities, and similar utilities.

2. **private utility.** A private utility is an entity that (a) performs or provides one or more utility services to its own facilities, such as a large industrial complex, large campus, military complex, railroad system, trolley system, or extensive gas or oil field through its own electric supply, communication, street and area lighting, or signal system and/or (b) generates or transmits power that is delivered to another utility.

   NOTE: Although many private utilities only operate a distribution level system, others operate generation and transmission systems.

utility interactive system. An electric power production system that is operating in parallel with and capable of delivering energy to a utility electric supply system.

utilization equipment. An electrical installation that uses electric or light energy for electronic, electromechanical, chemical, heating, lighting, testing, communication, signaling, or similar purposes on the premises wiring side of the service point.

NOTE: Utilization equipment and premises wiring on the load side of the service point is intended to be performed under the NEC, regardless of whether a utility has exclusive control.

vault. A structurally solid enclosure, including all sides, top, and bottom, that is (1) associated with an underground electric supply or communication system, (2) located either (a) above or below ground or (b) in a building, and (3) where entry is limited to personnel qualified to install, maintain, operate, or inspect the equipment or cable enclosed. The enclosure may have openings for ventilation, personnel access, cable entrance, and other openings required for operation of equipment in the vault.

voltage.

1. The effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.

2. **voltage of circuit not effectively grounded.** The highest nominal voltage available between any two conductors of the circuit.

   NOTE: If one circuit is directly connected to and supplied from another circuit of higher voltage (as in the case of an autotransformer), both are considered to be of the higher voltage, unless the circuit of the lower voltage is effectively grounded, in which case its voltage is not determined by the circuit of higher voltage. Direct connection implies electric connection as distinguished from connection merely through electromagnetic or electrostatic induction.

3. **voltage of a constant-current circuit.** The highest normal full-load voltage of the circuit.

4. **voltage of an effectively grounded circuit.** The highest nominal voltage available between any conductor of the circuit and ground unless otherwise indicated.

5. **voltage to ground of:**

   a. **a grounded circuit.** The highest nominal voltage available between any conductor of the circuit and that point or conductor of the circuit that is grounded.

   b. **an ungrounded circuit.** The highest nominal voltage available between any two conductors of the circuit concerned.

6. **voltage to ground of a conductor of:**
   a. **a grounded circuit.** The nominal voltage between such conductor and that point or conductor of the circuit that is grounded.
   b. **an ungrounded circuit.** The highest nominal voltage between such conductor and any other conductor of the circuit concerned.

wire gauges. Throughout these rules, the American Wire Gauge (AWG) is the standard gauge for copper, aluminum, and other conductors, excepting only steel conductors, for which the American Steel Wire Gauge (Stl WG) is used.

worksite (as applied to fall protection). The location on the structure or equipment where, after the worker has completed the climbing (horizontally and vertically), the worker is in position to perform the assigned work or task.

Section 3.
References

The following standards form a part of the NESC to the extent indicated in the rules herein.

ANSI C29.1-1988 (R2012), American National Standard Test Methods for Electrical Power Insulators. [Rules 272, 273, and Table 277-1]

ANSI C29.2 (Superseded) (1.2 standard deviation M&E), American National Standard for Wet-Process Porcelain and Toughened Glass Insulators (Suspension Type). [Rules 272, Table 277-1, 441B4b, and 441B4c]

ANSI C29.2A-2013, American National Standard for Distribution Class Insulators.

ANSI C29.2B-2013 (3.0 standard deviation M&E), American National Standard for Transmission Class Insulators.

ANSI C29.3-2012, American National Standard for Wet-Process Porcelain Insulators (Spool Type). [Rule 272 and Table 277-1]

ANSI C29.5-2012, American National Standard for Low- and Medium-Voltage Pin Type Wet-Process Porcelain Insulators. [Rule 272 and Table 277-1]

ANSI C29.6-2012, American National Standard for High-Voltage Pin Type Wet-Process Porcelain Insulators. [Rule 272 and Table 277-1]

ANSI C29.7-2012, American National Standard for High-Voltage Line-Post Type Wet-Process Porcelain Insulators. [Rule 272 and Table 277-1]

ANSI C29.8-2012, American National Standard for Wet-Process Porcelain Insulators—Apparatus, Cap, and Pin Type. [Table 277-1]

ANSI C29.9-2012, American National Standard for Wet-Process Porcelain Insulators—Apparatus, Post Type. [Table 277-1]

ANSI C29.12-2012, American National Standard for Insulators—Composite Suspension Type. [Table 277-1]

ANSI C29.13-2013, American National Standard for Insulators—Composite-Distribution Deadend Type. [Table 277-1]

ANSI C29.17-2002, American National Standard for Insulators—Composite-Line Post Type. [Table 277-1]

ANSI C29.18-2013, American National Standard for Insulators—Composite-Distribution Line Post Type. [Table 277-1]

ANSI O5.1-2015, American National Standard Specifications and Dimensions for Wood Poles. [Rule 261A2b(1)]

ANSI O5.2-2012, American National Standard for Wood Products—Structural Glued Laminated Timber for Utility Structures. [Rule 261A2b(2)]

ANSI O5.3-2008, American National Standard for Solid Sawn-wood Crossarms and Braces—Specifications and Dimensions. [Rule 261A2b(2)]

ANSI Z535.1-2011, American National Standard for Safety Colors. [Rules 110A1 NOTE, 112B NOTE, 124C1 NOTE, 146B NOTE, 180B11 NOTE, 180D2 NOTE, 217A1c NOTE, 217A2a NOTE, 323C4a NOTE, 323E3 NOTE, 381G2 NOTE, and 411D]

ANSI Z535.2-2011, American National Standard for Environmental Facility and Safety Signs. [Rules 110A1 NOTE, 112B NOTE, 124C1 NOTE, 146B NOTE, 180B11 NOTE, 180D2 NOTE, 217A1c NOTE, 217A2a NOTE, 323C4a NOTE, 323E3 NOTE, 381G2 NOTE, and 411D]

ANSI Z535.3-2011, American National Standard for Criteria for Safety Symbols. [Rules 110A1 NOTE, 112B NOTE, 124C1 NOTE, 146B NOTE, 180D2 NOTE, 180B11 NOTE, 217A1c NOTE, 217A2a NOTE, 323C4a NOTE, 323E3 NOTE, 381G2 NOTE, and 411D]

ANSI Z535.4-2011, American National Standard for Product Safety Signs and Labels. [Rules 110A1 NOTE, 112B NOTE, 124C1 NOTE, 146B NOTE, 180D2 NOTE, 180B11 NOTE, 217A1c NOTE, 217A2a NOTE, 323C4a NOTE, 323E3 NOTE, 381G2 NOTE, and 411D]

ANSI Z535.5-2011, American National Standard for Safety Tags and Barricade Tapes (for Temporary Hazards). [Rules 110A1 NOTE, 112B NOTE, 124C1 NOTE, 146B NOTE, 180B11 NOTE, 180D2 NOTE, and 411D]

ANSI/ASME B15.1:2000, ASME Standard for Mechanical Power Transmission Apparatus. [Rule 122A]

ANSI/SIA A92.2-1992, American National Standard for Vehicle Mounted Elevating and Rotating Aerial Devices. [Rule 446B1]

ASCE 7-2010, ASCE Standard for Minimum Design Loads for Buildings and Other Structures. [Rule 250C, Table 250-2 and Table 250-3]

ASCE 74-2010, Guidelines for Electrical Transmission Line Structure Loading. [Rule 250C]

ASTM D 178-01 (2010), ASTM Standard Specification for Rubber Insulating Matting. [Rule 124C4]

IEEE Std 4™-1995, IEEE Standard Techniques for High-Voltage Testing. [Table 410-2 and Table 410-3]

IEEE Std 516™-2009, IEEE Guide for Maintenance Methods on Energized Power-Lines.

IEEE Std 1427™-2006, IEEE Guide for Recommended Electrical Clearances and Insulation Levels in Air-Insulated Electrical Power Substations.

IEEE Std 1584™-2002, IEEE Guide for Performing Arc Flash Hazard Calculations. [Table 410-1, Footnotes 1, 3, 6, and 14]

IEEE Std C62.82.1™-2010, IEEE Standard for Insulation Coordination—Definitions, Principles, and Rules.

NFPA 30-2000, Flammable and Combustible Liquids Code. [Rule 127C, 127D, and 127F]

NFPA 30A-2000, Flammable and Combustible Liquids Code. [Rule 127E]

NFPA 58-2001, Storage and Handling of Liquefied Petroleum Gases. [Rule 127K]

NFPA 59-2001, Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants. [Rule 127K]

NFPA 59A-2001, Production, Storage, and Handling of Liquefied Natural Gas (LNG). [Rule 127L]

NFPA 70®, 2011 Edition, National Electrical Code® (NEC®). [Rules 011B4, 099C, 124C6a, and 127]

NFPA 496-1998, Standard for Purged and Pressurized Enclosures for Electrical Equipment. [Rule 127H]

NFPA 8503-1997, Standard for the Installation and Operation of Pulverized Fuel Systems. [Rule 127A5]

NOTE 1: The standards listed here were the editions used in this revision of the Code. In some cases, newer editions may be in effect. Contact the publisher for information about availability.

NOTE 2: ANSI publications are available from the American National Standards Institute (http://www.ansi.org/).

NOTE 3: ASCE publications are available from ASCE Publications (http://www.asce.org).

NOTE 4: ASTM publications are available from the American Society for Testing and Materials (http://www.astm.org/).

NOTE 5: IEEE publications are available from The Institute of Electrical and Electronics Engineers (http://standards.ieee.org).

NOTE 6: The IEEE standards or products referred to in this section are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

NOTE 7: NFPA publications are available from the National Fire Protection Association (http://www.nfpa.org/).

Section 9.
Grounding methods for electric supply and communications facilities

090. Purpose

The purpose of Section 9 of this Code is to provide practical methods of grounding, as one of the means of safeguarding employees and the public from injury that may be caused by electrical potential.

091. Scope

Section 9 of this Code covers methods of protective grounding of supply and communication conductors and equipment. The rules requiring grounding are in other parts of this Code. For rules requiring conductors or equipment to be effectively grounded, methods described in this section shall be used and the definition of effectively grounded shall be met.

These rules do not cover the grounded return of electric railways nor those lightning protection wires that are normally independent of supply or communication wires or equipment.

092. Point of connection of grounding conductor

A. Direct-current systems that are required to be grounded

1. 750 V and below

   Connection shall be made only at supply stations. In three-wire dc systems, the connection shall be made to the neutral.

2. Over 750 V

   Connection shall be made at both the supply and load stations. The connection shall be made to the neutral of the system. The ground or grounding electrode may be external to or remotely located from each of the stations.

   One of the two stations may have its grounding connection made through surge arresters provided the other station neutral is effectively grounded as described above.

   EXCEPTION: Where the stations are not geographically separated as in back-to-back converter stations, the neutral of the system should be connected to ground at one point only.

B. Alternating current systems that are required to be grounded

1. 750 V and below

   The point of the grounding connection on a wye-connected three-phase four-wire system, or on a single-phase three-wire system, shall be the neutral conductor. On other one-, two-, or three-phase systems with an associated lighting circuit or circuits, the point of grounding connection shall be on the common circuit conductor associated with the lighting circuits.

   The point of grounding connection on a three-phase three-wire system, whether derived from a delta-connected or an ungrounded wye-connected transformer installation not used for lighting, may be any of the circuit conductors, or it may be a separately derived neutral.

   The grounding connections shall be made at the source, and at the line side of all service equipment.

2. Over 750 V

   a. Nonshielded (bare or covered conductors or insulated nonshielded cables)

Grounding connection shall be made at the neutral of the source. Additional connections may be made, if desired, along the length of the neutral, where this is one of the system conductors.

b. Shielded

(1) Surge-arrester cable-shielding interconnection

Cable-shielding grounds shall be bonded to surge-arrester grounds, where provided, at points where underground cables are connected to overhead lines.

(2) Cable without insulating jacket

Connection shall be made to the neutral of the source transformer and at cable termination points.

(3) Cable with insulating jacket

Additional bonding and connections between the cable insulation shielding or sheaths and the system ground are recommended. Where multi-grounded shielding cannot be used for electrolysis or sheath-current reasons, the shielding sheaths and splice-enclosure devices shall be insulated for the voltage that may appear on them during normal operation.

Bonding transformers or reactors may be substituted for direct ground connection at one end of the cable.

3. Separate grounding conductor

If a separate grounding conductor is used as an adjunct to a cable run underground, it shall be connected either directly or through the system neutral to the source transformers, source transformer accessories, and cable accessories where these are to be grounded. This grounding conductor shall be located in the same direct burial or conduit run as the circuit conductors. If run in duct of magnetic material, the grounding conductor shall be run in the same duct as the circuit conductors.

EXCEPTION: The grounding conductor for a circuit that is installed in a magnetic duct need not be in the same duct if the duct containing the circuit is bonded to the separate grounding conductor at both ends.

C. Messenger wires and guys

1. Messenger wires

Messenger wires required to be grounded shall be connected to grounding conductors at poles or structures to total not less than the number of grounding locations shown below:

a. Where messenger wires are adequate for system grounding conductors (Rules 093C1, 093C2, and 093C5), four connections in each 1.6 km (1 mi).

EXCEPTION: Where the terrain (such as river crossings or mountainous areas) being crossed limits the installation of supporting structures every 0.4 km (0.25 mi) or less, the requirement of made electrodes to total not less than four grounds in each 1.6 km (1 mi) of the entire line does not apply for this portion if the messenger is of sufficient size and ampacity for the duty involved. However grounding connections to the messenger shall be made at all structures for this portion of the messenger.

b. Where messenger wires are not adequate for system grounding conductors, eight connections in each 1.6 km (1 mi), exclusive of service grounds.

2. Guys

Guys that are required to be effectively grounded shall be connected to one or more of the following:

a. An effectively grounded metallic supporting structure.

b. An effective ground on a nonmetallic supporting structure.

c. An effectively grounded neutral conductor.

3. Common grounding of messengers and guys on the same supporting structure

a. Where messengers and guys on the same supporting structure are required to be grounded, they shall be bonded together and grounded by connection to:

(1) One grounding conductor that is grounded at that structure, or to

(2) Separate grounding conductors or grounded messengers that are bonded together and grounded at that structure, or to

(3) One or more grounded line conductors or grounded messengers that are (a) bonded together at this structure or elsewhere and (b) multi-grounded elsewhere at intervals as specified in Rules 092C1 and 092C2.

b. At common crossing structures, messengers and guys that are required to be grounded shall be bonded together at that structure and grounded in accordance with Rule 092C3a.

EXCEPTION: This rule does not apply to guys that are connected to an effectively grounded overhead static wire.

D. Current in grounding conductor

Ground connection points shall be so arranged that under normal circumstances there will be no objectionable flow of current over the grounding conductor. If an objectionable flow of current occurs over a grounding conductor due to the use of multi-grounds, one or more of the following should be used:

1. Determine the source of the objectionable ground conductor current and take action necessary to reduce the current to an acceptable level at its source.
2. Abandon one or more grounds.
3. Change location of grounds.
4. Interrupt the continuity of the grounding conductor between ground connections.
5. Subject to the approval of the administrative authority, take other effective means to limit the current.

The system ground of the source transformer shall not be removed.

Under normal system conditions a grounding conductor current will be considered objectionable if the electrical or communication system's owner/operator deems such current to be objectionable, or if the presence and/or electrical characteristics of the grounding conductor current is in violation of rules and regulations governing the electrical system, as set forth by the authority having jurisdiction to promulgate such rules.

The temporary currents set up under abnormal conditions while the grounding conductors are performing their intended protective functions are not considered objectionable. The conductor shall have the capability of conducting anticipated fault current without thermal overloading or excessive voltage buildup. Refer to Rule 093C.

NOTE: Some amount of current will always be present on the grounding conductors of an operating ac electrical system.

E. Fences

Conductive electric supply station fences that are required to be grounded by Part 1 of this Code shall be designed to limit touch, step, and transferred voltages in accordance with industry practices.

NOTE: IEEE Std 80™-2000 [B32] is one source that may be utilized to provide guidance in meeting these requirements.

The grounding connections of electrical supply station fences shall be made either to the grounding system of the enclosed equipment or to a separate ground.

1. Conductive supply station fences shall be grounded at each side of a gate or other opening.
2. Conductive supply station fence gates shall be bonded to the grounding conductor, jumper, or fence.
3. A buried bonding jumper shall be used to bond across a gate or other opening in the supply station fence, unless a nonconducting fence section is used.

4. If barbed wire strands are used above the supply station fence fabric, the barbed wire strands shall be bonded to the grounding conductor, jumper, or fence.
5. When supply station fence posts are of conducting material, the grounding conductor shall be connected to the fence post or posts, as required, with suitable connecting means.
6. When supply station fence posts are of nonconducting material, suitable bonding connection shall be made to the fence mesh strands and the barbed wire strands at each grounding conductor point.

093. Grounding conductor and means of connection

A. Composition of grounding conductors

In all cases, the grounding conductor shall be made of copper or other metals or combinations of metals that will not corrode excessively during the expected service life under the existing conditions and, if practical, shall be without joint or splice. If joints are unavoidable, they shall be so made and maintained as to not materially increase the resistance of the grounding conductor and shall have appropriate mechanical and corrosion-resistant characteristics. For surge arresters and ground detectors, the grounding conductor or conductors shall be as short, straight, and free from sharp bends as practical. Metallic electrical equipment cases or the structural metal frame of a building or structure may serve as part of a grounding conductor to an acceptable grounding electrode.

In no case shall a circuit-opening device be inserted in the grounding conductor or connection except where its operation will result in the automatic disconnection from all sources of energy of the circuit leads connected to the equipment so grounded.

EXCEPTION 1: For dc systems over 750 V, grounding conductor circuit-opening devices shall be permitted for changing between a remote electrode and a local ground through surge arresters.

EXCEPTION 2: Temporary disconnection of grounding conductors for testing purposes, under competent supervision, shall be permitted.

EXCEPTION 3: Disconnection of a grounding conductor from a surge arrester is allowed when accomplished by means of a surge-arrester disconnector.

NOTE: The base of the surge arrester may remain at line potential following operation of the disconnector.

B. Connection of grounding conductors

Connection of the grounding conductor shall be made by a means matching the characteristics of both the grounded and grounding conductors, and shall be suitable for the environmental exposure. These means include brazing, welding, mechanical and compression connections, ground clamps, and ground straps. Soldering is acceptable only in conjunction with lead sheaths.

C. Ampacity and strength

For bare grounding conductors, the short time ampacity is the current that the conductor can carry for the time during which the current flows without melting or affecting the design characteristics of the conductor. For insulated grounding conductors, the short time ampacity is the current that the conductor can carry for the applicable time without affecting the design characteristics of the insulation. Where grounding conductors at one location are paralleled, the increased total current capacity may be considered.

1. System grounding conductors for single-grounded systems

   The system grounding conductor or conductors for a system with single-system grounding electrode or set of electrodes, exclusive of grounds at individual services, shall have a short time ampacity adequate for the fault current that can flow in the grounding conductors for the operating time of the system-protective device. If this value cannot be readily determined, continuous ampacity of the grounding conductor or conductors shall be not less than the full-load continuous current of the system supply transformer or other source of supply.

2. System grounding conductors for multi-grounded alternating current systems

   The system grounding conductors for an ac system with grounds at more than one location exclusive of grounds at individual services shall have continuous total ampacities at each location of not less than one-fifth that of the conductors to which they are attached. (See also Rule 093C8.)

3. Grounding conductors for instrument transformers

   The grounding conductor for instrument cases and secondary circuits for instrument transformers shall not be smaller than AWG No. 12 copper or shall have equivalent short time ampacity.

4. Grounding conductors for primary surge arresters

   The grounding conductor or conductors shall have adequate short time ampacity under conditions of excess current caused by or following a surge. Individual arrester grounding conductors shall be no smaller than AWG No. 6 copper or AWG No. 4 aluminum.

   EXCEPTION: Arrester grounding conductors may be copper-clad or aluminum-clad steel wire having not less than 30% of the conductivity of solid copper or aluminum wire of the same diameter, respectively.

   Where flexibility of the grounding conductor, such as adjacent to the base of the arrester, is vital to its proper operation, a suitably flexible conductor shall be employed.

5. Grounding conductors for equipment, messenger wires, and guys

   a. Conductors

      The grounding conductors for equipment, raceways, cable, messenger wires, guys, sheaths, and other metal enclosures for wires shall have short time ampacities adequate for the available fault current and operating time of the system fault-protective device. If no overcurrent or fault protection is provided, the ampacity of the grounding conductor shall be determined by the design and operating conditions of the circuit, but shall be not less than that of AWG No. 8 copper. Where the conductor enclosures and their attachment to the equipment enclosures are adequate and continuous, this path can constitute the equipment grounding conductor.

   b. Connections

      Connections of the grounding conductor shall be to a suitable lug, terminal, or device not disturbed in normal inspection, maintenance, or operation.

6. Fences

   The grounding conductor for fences required to be grounded by other parts of this Code shall meet the requirements of Rule 093C5 or shall be steel wire not smaller than Stl WG No. 5.

7. Bonding of equipment frames and enclosures

   Where required, a low-impedance metallic path shall be provided to conduct fault current back to the grounded terminal of the local supply. Where the supply is remote, the metallic path shall interconnect the equipment frames and enclosures with all other nonenergized conducting components within reach and shall additionally be connected to ground as outlined in Rule 093C5. Short time ampacities of bonding conductors shall be adequate for the duty involved.

8. Ampacity limit

   No grounding conductor need have greater ampacity than either:

   a. The phase conductors that would supply the ground fault current, or

   b. The maximum current that can flow through it to the ground electrode or electrodes to which it is attached. For a single grounding conductor and connected electrode or electrodes, this would be the supply voltage divided by the electrode resistance (approximately).

9. Strength

   All grounding conductors shall have mechanical strength suitable for the conditions to which they may reasonably be subjected.

   Furthermore, unguarded grounding conductors shall have a tensile strength not less than that of AWG No. 8 soft-drawn copper, except as noted in Rule 093C3.

D. Guarding and protection

1. Single-grounded systems: Guarding is required for grounding conductors of single-grounded systems unless the installation is not readily accessible to the public.
2. Multi-grounded systems: Grounding conductors of multi-grounded systems need not be guarded.
3. Where guarding is required, grounding conductors shall be protected by guards suitable for the exposure to which they may reasonably be subjected. The guards should extend for not less than 2.45 m (8 ft) above the ground or platform from which the grounding conductors are accessible to the public.
4. Where guarding is not required, grounding conductors, installed in areas of exposure to mechanical damage, shall be protected by being substantially attached closely to the surface of the pole or other structure and, where practical, on the portion of the structure having least exposure.
5. Guards used for grounding conductors of lightning-protection equipment shall be of nonmetallic materials if the guard completely encloses the grounding conductor or is not bonded at both ends to the grounding conductor.

E. Underground

1. Grounding conductors laid directly underground shall be laid slack or shall be of sufficient strength to allow for earth movement or settling that is normal at the particular location.
2. Direct-buried uninsulated joints or splices in grounding conductors shall be made with methods suitable for the application and shall have appropriate corrosion resistance, required permanence, appropriate mechanical characteristics, and required ampacity. The number of joints or splices should be the minimum practical.
3. Grounding cable insulation shielding systems shall be interconnected with all other accessible grounded power supply equipment in manholes, handholes, and vaults.

   EXCEPTION: Where cathodic protection or shield cross-bonding is involved, interconnection may be omitted.

4. Looped magnetic elements such as structural steel, piping, reinforcing bars, etc., should not separate grounding conductors from the phase conductors of circuits they serve.
5. Metals used for grounding, in direct contact with earth, concrete, or masonry, shall have been proven suitable for such exposure.

   NOTE 1: Under present technology, aluminum has not generally been proven suitable for such use.

   NOTE 2: Metals of different galvanic potentials that are electrically interconnected may require protection against galvanic corrosion.

6. Sheath transposition connections (cross-bonding)

   a. Where cable insulating shields or sheaths, which are normally connected to ground, are insulated from ground to minimize shield circulating currents, they shall be insulated from personnel contact at accessible locations. Transposition connections and bonding jumpers shall be insulated for nominal 600 V service, unless the normal shielding voltage exceeds this level, in which case the insulation shall be ample for the working voltage to ground.

   b. Bonding jumpers and connecting means shall be sized and selected to carry the available fault current without damaging jumper insulation or sheath connections.

F. Common grounding conductor for circuits, metal raceways, and equipment

Where the ampacity of a supply system grounding conductor is also adequate for equipment grounding requirements, this conductor may be used for the combined purpose. Equipment referred to includes the frames and enclosures of supply system control and auxiliary components, conductor raceways, cable shields, and other enclosures.

094. Grounding electrodes

The grounding electrode shall be permanent and adequate for the electrical system involved. A common electrode or electrode system shall be employed for grounding the electrical system and the conductor enclosures and equipment served by that system. This may be accomplished by interconnecting these elements at the point of connection of grounding conductor, Rule 092.

Grounding electrodes shall be one of the following:

A. Existing electrodes

Existing electrodes consist of conducting items installed for purposes other than grounding:

1. Metallic water piping system

Extensive metallic underground cold water piping systems may be used as grounding electrodes.

EXCEPTION: Water systems with nonmetallic, non-current-carrying pipe or insulating joints are not suitable for use as grounding electrodes.

NOTE: Such systems normally have very low resistance to earth and have been extensively used in the past.

2. Local systems

Isolated buried metallic cold water piping connecting to wells having sufficiently low measured resistance to earth may be used as grounding electrodes.

NOTE: Care should be exercised to ensure that all parts that might become disconnected are effectively bonded together.

3. Steel reinforcing bars in concrete foundations and footings

The reinforcing bar system of a concrete foundation or footing that is not insulated from direct contact with earth, and that extends at least 900 mm (3 ft) below grade, constitutes an effective and acceptable type of grounding electrode. Where steel supported on this foundation is to be used as a grounding conductor (tower, structure, etc.), it shall be interconnected by bonding between anchor bolts and reinforcing bars or by cable from the reinforcing bars to the structure above the concrete.

The normally applied steel ties are considered to provide adequate bonding between bars of the reinforcing cage.

NOTE: Where reinforcing bars in concrete are not suitably connected to a metal structure above the concrete, and the latter structure is subjected to grounding discharge currents (even connected to another electrode), there is likelihood of damage to the intervening concrete from ground-seeking current passing through the semiconducting concrete.

B. Made electrodes

1. General

Where made electrodes are used, they shall, as far as practical, penetrate permanent moisture level and below the frostline. Made electrodes shall be of metal or combinations of metals that do not corrode excessively under the existing conditions for the expected service life. For the purposes of this rule, stainless steel with appropriate non-corrosive properties is considered to be nonferrous metal.

All outer surfaces of made electrodes shall be conductive, that is, not having paint, enamel, or other covering of an insulating type.

2. Driven rods, buried wire, strips, or plates

The following made electrodes are considered equivalent for the purpose of this rule:

EXCEPTION: Other made electrodes may be used if their suitability is supported by a qualified engineering study.

a. Driven rods

(1) Driven rods may be sectional; the total length shall be not less than 2.45 m (8 ft). Iron, zinc-coated steel, or steel rods shall have a diameter of not less than 15.87 mm (0.625 in). Copper-clad, stainless steel, or stainless steel-clad rods shall have a diameter of not less than 12.7 mm (0.5 in).

(2) Longer rods or multiple rods may be used to reduce the ground resistance. Spacing between multiple rods should be not less than 1.8 m (6 ft).

EXCEPTION: Other diameters or configurations may be used if their suitability is supported by a qualified engineering study.

(3) Driven depth shall be not less than 2.45 m (8 ft). The upper end shall be flush with or below the ground level unless suitably protected.

EXCEPTION 1: Where rock bottom is encountered, driven depth may be less than 2.45 m (8 ft), or other types of electrode may be employed.

EXCEPTION 2: When contained within pad-mounted equipment, vaults, manholes, or similar enclosures, the driven depth may be reduced to 2.29 m (7.5 ft).

b. Buried wire, strips, or plates

In areas of high soil resistivity or shallow bedrock, or where lower resistance is required than attainable with driven rods, one or more of the following electrodes may be more useful:

(1) Wire

Bare wires 4 mm (0.162 in) in diameter or larger, conforming to Rule 093E5, buried in earth at a depth not less than 450 mm (18 in) and not less than 30 m (100 ft) total in length, laid approximately straight, constitute an acceptably made electrode. (This is frequently designated a counterpoise.) The wire may be in a single length or may be several lengths connected at ends or at some point away from the ends. The wire may take the form of a network with many parallel wires spaced in two-dimensional array, referred to as a grid.

EXCEPTION: Where rock bottom is encountered, burial depth may be less than 450 mm (18 in).

(2) Strips

Strips of metal not less than 3.0 m (10 ft) in total length and with total (two sides) surface not less than 0.47 m^2 (5 ft^2) buried in soil at a depth not less than 450 mm (18 in) constitute an acceptably made electrode. Ferrous metal electrodes shall be not less than 6 mm (0.25 in) in thickness and nonferrous metal electrodes not less than 1.5 mm (0.06 in).

NOTE: Strip electrodes are frequently useful in rocky areas where only irregularly shaped pits are practical to excavate.

(3) Plates or sheets

Metal plates or sheets having not less than 0.185 m^2 (2 ft^2) of surface exposed to the soil, and at a depth of not less than 1.5 m (5 ft), constitute an acceptable made electrode. Ferrous metal electrodes shall be not less than 6 mm (0.25 in) in thickness and nonferrous metal electrodes not less than 1.5 mm (0.06 in).

3. Pole-butt plates and wire wraps

   a. General

      In areas of very low soil resistivity there are two constructions, described in specifications b and c below, that may provide effective grounding electrode functions although they are inadequate in most other locations. Where these have been proven to have adequately low earth resistance by the application of Rule 096, two such electrodes may be counted as one made electrode and ground for application of Rules 092C1a, 092C2b, 096C, and 097C; however, these types shall not be the sole grounding electrode at transformer locations.

   b. Pole-butt plates

      Subject to the limitations of Rule 094B3a, a pole-butt plate on the base of a wooden pole, possibly folded up around the base of the pole butt, may be considered an acceptable electrode in locations where the limitations of Rule 096 are met. The plates shall be not less than 6 mm (1/4 in) thick if of ferrous metal and not less than 1.5 mm (0.06 in) thick if of nonferrous metal. Further, the plate area exposed to the soil shall be not less than 0.046 m^2 (0.5 ft^2).

   c. Wire wrap

      Subject to the limitations of Rule 094B3a, made electrodes may be wire attached to the pole previous to the setting of the pole. The wire shall be of copper or other metals that will not corrode excessively under the existing conditions and shall have a continuous bare or exposed length below ground level of not less than 3.7 m (12 ft), shall extend to the bottom of the pole, and shall not be smaller than AWG No. 6.

4. Concentric neutral cable

   Systems employing extensive [30 m (100 ft) minimum length] buried bare concentric neutral cable in contact with the earth may employ the concentric neutral as a grounding electrode. The concentric neutral may be covered with a semi-conducting jacket that has a radial resistivity not exceeding 100 m · Ω and that will remain essentially stable in service. The radial resistivity of the jacket material is that value calculated from measurements on a unit length of cable, of the resistance between the concentric neutral and a surrounding conducting medium. Radial resistivity equals resistance of unit length times the surface area of jacket divided by the average thickness of the jacket over the neutral conductors. All dimensions are to be expressed in meters.

5. Concrete-encased electrodes

   A metallic wire, rod, or structural shape, meeting Rule 093E5 and encased in concrete, that is not insulated from direct contact with earth, shall constitute an acceptable ground electrode. The concrete depth below grade shall be not less than 300 mm (1 ft), and a depth of 750 mm (2.5 ft) is recommended. Wire shall be no smaller than AWG No. 4 if copper, or 9 mm (3/8 in) diameter or AWG No. 1/0 if steel. It shall be not less than 6.1 m (20 ft) long, and shall remain entirely within the concrete except for the external connection. The conductor should be run as straight as practical.

   The metal elements may be composed of a number of shorter lengths arrayed within the concrete and connected together (e.g., the reinforcing system in a structural footing).

   EXCEPTION: Other wire length or configurations may be used if their suitability is supported by a qualified engineering study.

   NOTE 1: The lowest resistance per unit wire length will result from a straight wire installation.

   NOTE 2: The outline of the concrete need not be regular, but may conform to an irregular or rocky excavation.

   NOTE 3: Concrete-encased electrodes are frequently more practical or effective than driven rods or strips or plates buried directly in earth.

6. Directly embedded metal poles

Directly embedded steel poles shall constitute an acceptable electrode, if both the following requirements are met:

a. Backfill around the pole is native earth, concrete, or other conductive material and

b. Not less than 1.5 m (5.0 ft) of the embedded length is exposed directly to the earth, without nonconductive covering

Aluminum installed belowground is not an acceptable electrode.

EXCEPTION: Other lengths, configurations, or type metal may be used if their suitability is supported by a qualified engineering study.

NOTE 1: Weathering steel may not be an acceptable material for this application.

NOTE 2: There are structural and corrosion concerns that should be investigated prior to using metal poles as grounding electrodes. See Sections 25 and 26.

095. Method of connection to electrode

A. Ground connections

The grounding connection shall be as accessible as practical and shall be made to the electrode by methods that provide the required permanence, appropriate mechanical characteristics, corrosion resistance, and required ampacity such as:

1. An effective clamp, fitting, braze, or weld.
2. A bronze plug that has been tightly screwed into the electrode.
3. For steel-framed structures, employing a concrete-encased reinforcing bar electrode, a steel rod similar to the reinforcing bar shall be used to join, by welding, a main vertical reinforcing bar to an anchor bolt. The bolt shall be substantially connected to the baseplate of the steel column supported on that footing. The electrical system may then be connected (for grounding) to the building frame by welding or by a bronze bolt tapped into a structural member of that frame.
4. For nonsteel frame structures employing a concrete-encased rod or wire electrode, an insulated copper conductor of size meeting the requirements of Rule 093C (except not smaller than AWG No. 4) shall be connected to the steel rod or wire using a cable clamp suitable for steel cable. This clamp and all the bared portion of the copper conductor, including ends of exposed strands within the concrete, shall be completely covered with mastic or sealing compound before concrete is poured. The copper conductor end shall be brought to or out of the concrete surface at the required location for connection to the electrical system. If the copper wire is carried beyond the surface of the concrete, it shall be no smaller than AWG No. 2.

   Alternately, the copper wire may be brought out of the concrete at the bottom of the hole and carried external to the concrete for surface connection.

B. Point of connection to piping systems

1. The point of connection of a grounding conductor to a metallic water piping system shall be as near as is practical to the water-service entrance to the building or near the equipment to be grounded and shall be accessible. If a water meter is between the point of connection and the underground water pipe, the metallic water piping system shall be made electrically continuous by bonding together all parts between the connection and the pipe entrance that may become disconnected, such as meters and service unions.
2. Made grounds or grounded structures should be separated by 3.0 m (10 ft) or more from pipelines used for the transmission of flammable liquids, or gases operating at high pressure [1030 kPa (150 lb/in^2) or greater], unless they are electrically interconnected and cathodically protected as a single unit. Grounds within 3.0 m (10 ft) of such pipelines should be avoided or

shall be coordinated so that hazardous ac conditions will not exist and cathodic protection of the pipeline will not be nullified.

RECOMMENDATION: It is recommended that calculations or tests be used to determine the required separation of ground electrodes for high-voltage direct-current (HVDC) systems from flammable liquid or high-pressure gas pipelines.

NOTE: Ground electrodes for HVDC systems over 750 V may require greater separation.

C. Contact surfaces

If any coating of nonconducting material, such as enamel, rust, or scale, is present on electrode contact surfaces at the point of connection, such a coating shall be thoroughly removed where required to obtain the requisite good connection. Special fittings so designed as to make such removal of nonconducting coatings unnecessary may also be used.

096. Ground resistance requirements

A. General

Grounding systems shall be designed to minimize hazard to personnel and shall have resistances to ground low enough to permit prompt operation of circuit protective devices. Grounding systems may consist of buried conductors and grounding electrodes.

B. Supply stations

Supply stations may require extensive grounding systems consisting of multiple buried conductors, grounding electrodes, or interconnected combinations of both. Grounding systems shall be designed to limit touch, step, mesh, and transferred potentials in accordance with industry practices.

NOTE: IEEE Std 80-2000 [B32] is one source that may be utilized to provide guidance in meeting these requirements.

C. Multi-grounded systems

The neutral, which shall be of sufficient size and ampacity for the duty involved, shall be connected to a made or existing electrode at each transformer location and at a sufficient number of additional points with made or existing electrodes to total not less than four grounds in each 1.6 km (1 mi) of the entire line, not including grounds at individual services.

EXCEPTION 1: Where cable or cable in duct is installed under water, the requirement of made electrodes to total not less than four grounds in each 1.6 km (1 mi) of the entire line does not apply for the underwater portion if the neutral is of sufficient size and ampacity for the duty involved and the requirements of Rule 092B2 are met. However, at all locations where the cable is accessible to personnel, the neutral shall be effectively grounded.

EXCEPTION 2: For cable or cable in duct installed underground where adherence to a total of not less than four grounds in each 1.6 km (1 mi) would require removing the protective jacket of a buried cable, only to install a ground to meet this rule, the requirement of a total of not less than four grounds in each 1.6 km (1 mi) need not be met. However, at all locations where the cable is accessible to personnel, the neutral shall be effectively grounded.

EXCEPTION 3: Where the terrain (such as river crossings or mountainous areas) being crossed limits the installation of supporting structures every 0.4 km (0.25 mi) or less, the requirement of made electrodes to total not less than four grounds in each 1.6 km (1 mi) of the entire line does not apply for this portion if the neutral is of sufficient size and ampacity for the duty involved. However all available structures should be grounded.

NOTE 1: This rule may be applied to shield wire(s) grounded at the source and which meet the multi-grounding requirements of this rule.

NOTE 2: Multi-grounded systems extending over a substantial distance are more dependent on the multiplicity of grounding electrodes than on the resistance to ground of any individual electrode. Therefore, no specific values are imposed for the resistance of individual electrodes.

NOTE 3: The intent is to ensure that grounding electrodes are distributed at approximately 400 m (1/4 mi) or smaller intervals, although some intervals may exceed 400 m (1/4 mi).

D. Single-grounded (unigrounded or delta) systems

The ground resistance of an individual made electrode used for a single-grounded system should meet the requirements of Rule 096A and should not exceed 25 Ω. If a single electrode resistance cannot meet these requirements, then other methods of grounding as described in Rule 094B shall be used to meet the requirements of Rule 096A.

097. Separation of grounding conductors

A. Except as permitted in Rule 097B, grounding conductors from equipment and circuits of each of the following classes shall be run separately to the grounding electrode for each of the following classes:

1. Surge arresters of circuits over 750 V and frames of any equipment operating at over 750 V.
2. Lighting and power circuits under 750 V.
3. Shield wires of power circuits.
4. Lightning rods, unless attached to a grounded metal supporting structure.

Alternatively, the grounding conductors shall be run separately to a sufficiently heavy ground bus or system ground cable that is well connected to ground at more than one place.

B. The grounding conductors of the equipment classes detailed in Rules 097A1, 097A2, and 097A3 may be interconnected utilizing a single grounding conductor, provided:

1. There is a direct-earth grounding connection at each surge-arrester location, and
2. The secondary neutral or the grounded secondary phase conductor is common with or connected to a primary neutral or a shield wire meeting the grounding requirements of Rule 097C.

C. Primary and secondary circuits utilizing a single conductor as a common neutral shall have at least four ground connections on such conductor in each 1.6 km (1 mi) of line, exclusive of ground connections at customers' service equipment.

D. Ungrounded or single-grounded systems and multi-grounded systems

1. Ungrounded or single-grounded systems

Where the secondary neutral is not interconnected with the primary surge-arrester grounding conductor as in Rule 097B, interconnection may be made through a spark gap or device that performs an equivalent function. The gap or device shall have a 60 Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV. At least one other grounding connection on the secondary neutral shall be provided with its grounding electrode located at a distance of not less than 6.1 m (20 ft) from the surge-arrester grounding electrode in addition to customer's grounds at each service entrance. The primary grounding conductor, or the secondary grounding conductor, shall be insulated for 600 V.

NOTE: For single-grounded systems, also see Rules 093C1, 093D, and 096D.

2. Multi-grounded systems

On multi-grounded systems, the primary and secondary neutrals should be interconnected according to Rule 097B. However, where it is necessary to separate the neutrals, interconnection of the neutrals shall be made through a spark gap or a device that performs an equivalent function. The gap or device shall have a 60 Hz breakdown voltage not exceeding 3 kV. At least one other grounding connection on the secondary neutral shall be provided with its grounding electrode located at a distance not less than 1.80 m (6 ft) from the primary neutral and surge-arrester grounding electrode in addition to the customer's grounds at each service entrance. Where the primary and secondary neutrals are not directly interconnected, (a) the primary grounding conductor, or the secondary grounding conductor, or both, shall be insulated for 600 V, and (b) the secondary grounding conductor shall be guarded according to Rule 093D3.

NOTE 1: A difference of voltage can exist where primary and secondary neutrals are not directly interconnected. For example, where metallic equipment is bonded to the secondary grounding conductor and is installed on the same pole, the primary grounding conductor would be insulated.

NOTE 2: Cooperation of all communications and supply utilities, customers of these utilities, and others may be necessary to obtain effective isolation between primary and secondary neutrals.

E. Where separate electrodes are used for system isolation, separate grounding conductors shall be used. Where multiple electrodes are used to reduce grounding resistance, they may be bonded together and connected to a single grounding conductor.

F. Made electrodes used for grounding surge arresters of ungrounded supply systems operated at potentials exceeding 15 kV phase to phase should be located at least 6.1 m (20 ft) from buried communication cables. Where lines with lesser separations are to be constructed, reasonable advance notice should be given to the owners or operators of the affected systems.

G. Bonding of communication systems to electric supply systems

Where both electric supply systems and communication systems are grounded on a joint-use structure and a single grounding conductor is present, the grounding conductor shall be connected to both systems. Where separate supply and communication grounding conductors are used, they shall be bonded together.

EXCEPTION 1: Where separation is required by Rule 097A.

EXECPTION 2: Where the electric supply utility is maintaining isolation between primary and secondary neutrals, the communication system ground shall be connected only to the primary grounding conductor if it complies with the requirements of Rule 097C.

098. Number 098 not used in this edition.

099. Additional requirements for grounding and bonding of communication apparatus

Where required to be grounded by other parts of this Code, communication apparatus shall be grounded in the following manner.

See *NOTE 2* in Rule 097D2.

A. Electrode

The grounding conductor shall be connected to an acceptable grounding electrode as follows:

1. Where available and where the supply service is grounded to an acceptable electrode, as described in Rule 094, to the grounded metallic supply service conduit, service equipment enclosure, grounding electrode conductors, or grounding electrode conductors' metal enclosure.
2. Where the grounding means of Rule 099A1 is not available, to a grounding electrode as described in Rule 094A.
3. Where the grounding means of Rule 099A1 or 099A2 are not available, to a grounding electrode as described in Rule 094B.

   EXCEPTION: A variance to Rule 094B2 is allowed for this application. Iron or steel rods may have a cross-sectional dimension of not less than 13 mm (0.50 in) and a length of not less than 1.50 m (5 ft). The driven depth shall be 1.50 m (5 ft), subject to *EXCEPTION 1* of Rule 094B2.

B. Electrode connection

The grounding conductor shall preferably be made of copper (or other material that will not corrode excessively under the prevailing conditions of use) and shall be not less than AWG No. 6 in size. The grounding conductor shall be attached to the electrode by means of a bolted clamp or other suitable methods.

NOTE: For requirements on proper materials, methods, and precautions to be taken in the selection and application of grounding and bonding, refer to Rules 093B and 095.

C. Bonding of electrodes

A bond not smaller than AWG No. 6 copper or equivalent shall be placed between the communication grounding electrode and the supply system neutral grounding electrode where separate electrodes are used at the structure or building being served. All separate electrodes shall be bonded together except where separation is required per Rule 097.

RECOMMENDATION: If water piping is used as a bonding means, care must be taken that the metallic path is continuous between electrodes.

NOTE 1: See NEC Article 800-100(D) for corresponding NEC requirements.

NOTE 2: The bonding together of all separate electrodes limits potential differences between them and between their associated wiring systems.

Part 1.
Safety Rules for the Installation and Maintenance of Electric Supply Stations and Equipment

Section 10.
Purpose and scope of rules

100. Purpose

The purpose of Part 1 of this Code is the practical safeguarding of persons during the installation, operation, or maintenance of electric supply stations and their associated equipment.

101. Scope

Part 1 of this Code covers the electric supply conductors and equipment, along with the associated structural arrangements in electric supply stations, that are accessible only to qualified personnel. It also covers the conductors and equipment employed primarily for the utilization of electric power when such conductors and equipment are used by the utility in the exercise of its function as a utility.

102. Application of rules

The general requirements for application of these rules are contained in Rule 13.

103. Referenced sections

The Introduction (Section 1), Definitions (Section 2), References (Section 3), and Grounding methods (Section 9) shall apply to the requirements of Part 1.

Section 11.
Protective arrangements in electric supply stations

110. General requirements

A. Enclosure of equipment

1. Types of enclosures

Rooms and spaces in which electric supply conductors or equipment are installed shall be so arranged with barriers, such as fences, screens, partitions, or walls, to form an enclosure as to limit the likelihood of entrance of unauthorized persons or interference by them with equipment inside. Entrances not under observation of an authorized attendant shall be kept locked. An installed barrier may be satisfied with any one of the following:

a. Fence fabric, not less than 2.13 m (7 ft) in height.

b. A combination of 1.8 m (6 ft) or more of fence fabric and an extension utilizing three or more strands of barbed wire to achieve an overall height of the fence of not less than 2.13 m (7 ft).

c. Other types of construction, not less than 2.13 m (7 ft), that present equivalent barriers to climbing or other unauthorized entry.

A safety sign shall be displayed on or beside the door or gate at each entrance. For fenced or walled electric supply stations without roofs, a safety sign shall be displayed on each exterior side of the fenced or wall enclosure. Where the station is entirely enclosed by walls and roof, a safety sign is required only at ground level entrances. Where entrance is gained through sequential doors, the safety sign should be located at the inner door position.

NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, ANSI Z535.4-2011, and ANSI Z535.5-2011 contain information regarding safety signs.

Metal fences or other metallic barriers, when used to enclose electric supply stations having energized electric conductors or equipment, shall be grounded in accordance with Section 9.

No fence or similar structure shall be allowed to be connected to or located within 2.8 m (6.0 ft) of an electric supply station fence without the concurrence of the substation owner.

2. Safety clearance zone

Fences or walls, when installed as barriers for unauthorized personnel, shall be located such that exposed live parts are outside the safety clearance zone depending on the type of barrier, as follows:

a. A metal chain-link fence or equivalent barrier, as illustrated in Table 110-1, shall have an R-value equal to or greater than that specified in Figure 110-1.

b. Where an impenetrable barrier is used, such as a fence, partition, or wall with no openings through which sticks or other objects can be inserted, the safety zone clearance calculation may be modified to account for the protection offered by the barrier. The sum of the height of the impenetrable barrier (H) and the distance from that point to the closest energized part (R1) must be greater than or equal to the sum of the dimension R and 1.5 m (5 ft).

$$R1 + H \geq R + 1.5 \text{ m (5 ft)}$$

where

H = Height of impenetrable barrier
R1 = Distance between point at height H and the closest energized part
R = Dimension from Table 110-1

It is acceptable to have a barrier comprised of both penetrable and impenetrable portions. If there are openings in the barrier below the impenetrable portions, the clearance from the lowest impenetrable point to the closest energized part shall be not less than the dimension R from Table 110-1.

Dimension R1 as illustrated in Figure 110-2 is a variable dimension, which is dependent upon the values of R and H.

EXCEPTION: The safety clearance zone requirement is not applicable to internal fences within an electric supply station perimeter.

B. Rooms and spaces

All rooms and spaces in which electric supply equipment is installed shall comply with the following requirements:

1. Construction

They shall be as much as practical noncombustible.

NOTE: This rule is not intended to prevent wood poles from being used to support conductors or equipment in electric supply stations.

2. Use

They should be as much as practical free from combustible materials, dust, and fumes and shall not be used for manufacturing or for storage.

EXCEPTION 1: Material, equipment, and vehicles essential for maintenance of the installed equipment may be stored if guarded or separated from live parts as required by Rule 124.

EXCEPTION 2: Material, equipment, and vehicles related to station, transmission and distribution construction, operations, or maintenance work may be stored in the station if located in an area separated from the station electric supply equipment by a fence meeting the requirements of Rule 110A.

EXCEPTION 3: Material, equipment, and vehicles related to station, transmission, and distribution construction, operations, or maintenance work in progress may be temporarily located in a storage space meeting all of the following requirements:

(a) Guarded or separated from live parts as required by Rule 124.

(b) Station exits continue to meet the requirements of Rule 113.

(c) Station working space continues to meet the requirements of Rule 125.

(d) Access is limited to qualified personnel and persons escorted by qualified personnel.

(e) The storage location and content is such that the risk of fire does not unreasonably jeopardize station operation.

(For battery areas, see Section 14; for guarding, see Rule 124; for auxiliary equipment in classified locations, see Rule 127.)

3. Ventilation

There should be sufficient ventilation to maintain operating temperatures within ratings, arranged to minimize accumulation of airborne contaminants under any operating conditions.

4. Moisture and weather

They should be dry. In outdoor stations or stations in wet tunnels, subways or other moist or high-humidity locations, the equipment shall be suitably designed to withstand the prevailing atmospheric conditions.

C. Electric equipment

All stationary equipment shall be supported and secured in a manner consistent with reasonably expected conditions of service. Consideration shall be given to the fact that certain heavy equipment, such as transformers, can be secured in place by their weight. However, equipment that generates dynamic forces during operation may require appropriate additional measures.

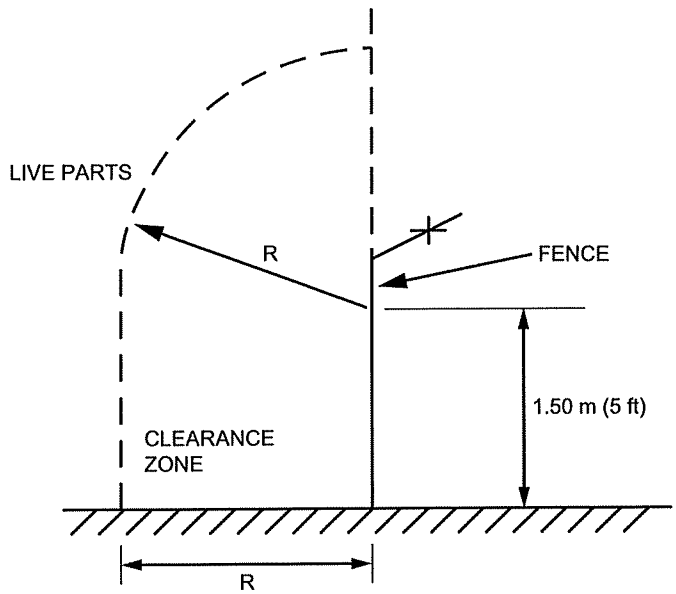


Figure 110-1—Safety clearance to electric supply station fences

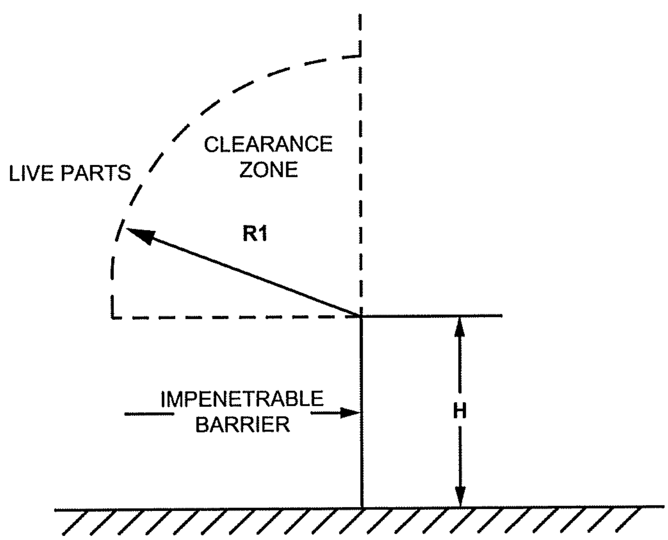


Figure 110-2—Safety clearance to electric supply station impenetrable fence

Table 110-1—Values for use with Figure 110-1

Nominal voltage between phases	Typical BIL	Dimension "R"		
		m	ft	in
151–7200	95	3.0	10	0
13 800	110	3.1	10	1
23 000	150	3.1	10	4
34 500	200	3.2	10	7
46 000	250	3.3	10	11
69 000	350	3.5	11	7
115 000	550	4.0	13	0
138 000	650	4.2	13	8
161 000	750	4.4	14	4
230 000	825	4.5	14	11
230 000	900	4.7	15	5
345 000	1050	5.0	16	5
345 000	1175	5.3	17	4
345 000	1300	5.5	18	4
500 000	1550	6.0	19	10
500 000	1800	6.6	21	6
765 000	2050	7.1	23	5

NOTE: The values are for altitudes of 1000 m (3300 ft) or less. For higher altitudes refer to Rule 124A1.

111. Illumination

A. Under normal conditions

1. Outdoor lighting is not required at unattended stations. Permanent or portable lighting may be used during such times that personnel perform work in the station at night.

2. Rooms and spaces shall have provisions for artificial illumination while attended. Illumination levels not less than those listed in Table 111-1 are recommended for safety to be maintained on the task.

B. Emergency lighting

1. A separate emergency source of illumination with automatic initiation, from an independent generator, storage battery, or other suitable source, shall be provided in every attended station.

2. Emergency lighting of 11 lux (1 footcandle) shall be provided in exit paths from all areas of attended stations. Consideration must be given to the type of service to be rendered, whether of

short or long duration. The minimum duration shall be 1-1/2 h. It is recommended that emergency circuit wiring shall be kept independent of all other wiring and equipment.

C. Fixtures

Arrangements for permanent fixtures and plug receptacles shall be such that portable cords need not be brought into dangerous proximity to live or moving parts. All lighting shall be controlled and serviced from safely accessible locations.

D. Attachment plugs and receptacles for general use

Portable conductors shall be attached to fixed wiring only through separable attachment plugs that will disconnect all poles by one operation. Receptacles installed on two- or three-wire single-phase, ac branch circuits shall be of the grounding type. Receptacles connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable.

E. Receptacles in damp or wet locations

All 120 V ac permanent receptacles shall either be provided with ground-fault interrupter (GFI) protection or be on a grounded circuit that is tested at such intervals as experience has shown to be necessary.

Table 111-1—Illumination levels

Location	lux	footcandles
Generating station (interior)		
Highly critical areas occupied most of the time ①	270	25
Areas occupied most of the time ②	160	15
Critical areas occupied infrequently ③	110	10
Areas occupied infrequently ④	55	5
Generating station (exterior)		
Building pedestrian main entrance	110	10
Critical areas ⑤	55	5
Areas occupied occasionally by pedestrians ⑥	22	2
Areas occupied occasionally by vehicles ⑦	11	1
Areas occupied infrequently ⑧	5.5	0.5
Remote areas ⑨	2.2	0.2
Substation		
Control building interior	55	5
General exterior horizontal and equipment vertical	22	2
Remote areas ⑩	2.2	0.2

① Such as: Chemical laboratory, large centralized control room 1.68 m (66 in) above floor, section of duplex facing away from operator, bench boards (horizontal level), dispatch boards—horizontal plane (desk level), dispatch boards—vertical face of board [1.22 m (48 in) above floor, facing operator]—system load dispatch room.

② Such as: Ordinary control room 1.68 m (66 in) above floor, secondary dispatch room, turbine room.

③ Such as: Auxiliaries, battery areas, boiler feed pumps, tanks, compressors, gage area, burner platforms, hydrogen and carbon dioxide manifold area, screen house, power switchgear, communications equipment room, turbine bay sub-basement, visitors' gallery, water treating area.

④ Such as: Air-conditioning equipment, air preheater and fan floor, ash sluicing, boiler platforms, cable room, circulator, or pump bay, coal conveyor, crusher, feeder, scale area, pulverizer, fan area, transfer tower, condensers, de-aerator floor, evaporator floor, heater floors, area inside duplex switchboards, rear of all switchboard panels (vertical), precipitators, soot or slag blower platform, steam headers and throttles, piping tunnels or galleries.

⑤ Such as: Coal unloading dock (loading or unloading zone), coal unloading car dumper, gate house conveyor entrance, fuel-oil delivery headers, platforms—boiler, turbine deck.

⑥ Such as: Catwalks, coal unloading tipple, conveyers, secondary building entrances.

⑦ Such as: Oil storage tanks, roadway between or along buildings.

⑧ Such as: Coal unloading barge storage area, roadway not bordered by buildings.

⑨ Such as: Cinder dumps, fence, open yard.

⑩ Such as: Fence, open yard.

112. Floors, floor openings, passageways, and stairs

A. Floors

Floors shall have even surfaces and afford secure footing. Slippery floors or stairs should be provided with antislip covering.

B. Passageways

Passageways, including stairways, shall be unobstructed and shall, where practical, provide at least 2.13 m (7 ft) head room. Where the preceding requirements are not practical, the obstructions should be painted, marked, or indicated by safety signs, and the area properly lighted.

NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, ANSI Z535.4-2011, and ANSI Z535.5-2011 contain information regarding safety signs.

C. Railings

All floor openings without gratings or other adequate cover and raised platforms and walkways in excess of 300 mm (1 ft) in height shall be provided with railings. Openings in railings for units such as fixed ladders, cranes, and the like shall be provided with adequate guards such as grates, chains, or sliding pipe sections.

D. Stair guards

All stairways consisting of four or more risers shall be provided with handrails.

NOTE: For additional information, see ANSI/ASSE A1264.1-2007 [B13].

E. Top rails

All top rails shall be kept unobstructed for a distance of 75 mm (3 in) in all directions except from below at supports.

113. Exits

A. Clear exits

Each room or space and each working space about equipment shall have a means of exit, which shall be kept clear of all obstructions.

B. Double exits

If the plan of the room or space and the character and arrangement of equipment are such that an accident would be likely to close or make inaccessible a single exit, a second exit shall be provided.

C. Exit doors

Exit doors shall swing out and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

EXCEPTION: This rule does not apply to exit doors in buildings and rooms containing low-voltage, nonexplosive equipment, and to gates in fences for outdoor equipment installations.

Section 12.
Installation and maintenance of equipment

120. General requirements

A. All electric equipment shall be constructed, installed, and maintained so as to safeguard personnel as far as practical.

B. The rules of this section are applicable to both ac and dc supply stations.

121. Inspections

A. In-service equipment

Electric equipment shall be inspected and maintained at such intervals as experience has shown to be necessary. Equipment or wiring found to be defective shall be put in good order or permanently disconnected.

B. Idle equipment

Infrequently used equipment or wiring shall be inspected and tested before use to determine its fitness for service. Idle equipment energized but not connected to a load shall be inspected and maintained at such intervals as experience has shown to be necessary.

C. Emergency equipment

Equipment and wiring maintained for emergency service shall be inspected and tested at such intervals as experience has shown to be necessary to determine its fitness for service.

D. New equipment

New equipment shall be inspected and tested before being placed in service. New equipment shall be tested in accordance with standard industry practices.

122. Guarding shaft ends, pulleys, belts, and suddenly moving parts

A. Mechanical transmission machinery

The methods for safeguarding pulleys, belts, and other equipment used in the mechanical transmission of power shall be in accordance with ANSI/ASME B15.1:2000.

B. Suddenly moving parts

Parts of equipment that move suddenly in such a way that persons in the vicinity are likely to be injured by such movement shall be guarded or isolated.

123. Protective grounding

A. Protective grounding or physical isolation of non-current-carrying metal parts

All electric equipment shall have the exposed non-current-carrying metal parts, such as frames of generators and switchboards, cases of transformers, switches, and operating levers, effectively grounded or physically isolated. All metallic guards including rails, screen fences, etc., about electric equipment shall be effectively grounded.

B. Grounding method

All grounding that is intended to be a permanent and effective protective measure, such as surge-arrester grounding, grounding of circuits, equipment, or wire raceways, shall be made in accordance with the methods specified in Section 9 of this Code.

NOTE: For additional information, see IEEE Std 80-2000 [B32].

C. Provision for grounding equipment during maintenance

Electric equipment or conductors normally operating at more than 600 V between conductors, on or about which work is occasionally done while isolated from a source of electric energy by disconnecting or isolating switches only, shall be provided with some means for grounding, such as switches, connectors, or a readily accessible means for connecting a portable grounding conductor. See Part 4 of this Code.

D. Grounding methods for direct-current systems over 750 V

On dc systems greater than 750 V, the dc system shall be grounded in accordance with the methods specified in Section 9 of this Code.

124. Guarding live parts

A. Where required

1. Guards shall be provided around all live parts operating above 300 V phase-to-phase without an adequate insulating covering, unless their location gives sufficient horizontal or vertical clearance or a combination of these clearances to limit the likelihood of accidental human contact, and the location of the live parts is in compliance with the Safety Clearance Zone requirements of Rule 110A2. Clearances from live parts to any permanent supporting surface for workers shall equal or exceed either of those shown in Table 124-1 and illustrated in Figure 124-1. The values listed in Table 124-1 and Table 110-1 are for altitudes of 1000 m (3300 ft) or less. For higher altitudes, appropriate atmospheric correction factors shall be applied.

   NOTE: For additional information, see IEEE Std C37.100.1™-2007 [B57] and IEEE Std 1427™-2006.

   EXCEPTION: Where supplemental protection is used in accordance with Rule 124C3, the requirements to guard do not apply.

2. Parts over or near passageways through which material may be carried, or in or near spaces such as corridors, storerooms, and boiler rooms used for nonelectrical work, shall be guarded or given clearances in excess of those specified such as may be necessary to secure reasonable safety. The guards shall be substantial and completely shield or enclose the live parts without openings. In spaces used for nonelectrical work, guards should be removable only by means of tools or keys.

3. Each portion of parts of indeterminate potential, such as communications lines exposed to induction from high-voltage lines, ungrounded neutral connections, ungrounded frames, ungrounded parts of insulators or surge arresters, or ungrounded instrument cases connected directly to a high-voltage circuit, shall be guarded in accordance with Rule 124A1 on the basis of the maximum voltage that may be present on the surface of that portion. The vertical clearance above any permanent supporting surface for workers to the bottom of such part shall be not less than 2.60 m (8.5 ft) unless it is enclosed or guarded in accordance with Rule 124C or Rule 124D.

B. Strength of guards

Guards shall be sufficiently strong and shall be supported rigidly and securely enough to limit the likelihood of them being displaced or dangerously deflected by a person slipping or falling against them.

C. Types of guards

1. Location or physical isolation

Live parts in compliance with the Rule 110A2 Safety Clearance Zone requirements and having clearances equal to or greater than specified in Table 124-1 are guarded by location. Parts are guarded by isolation when all entrances to enclosed spaces, runways, fixed ladders, and the like are kept locked, barricaded, or roped off, and safety signs are posted at all entrances.

NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, ANSI Z535.4-2011, and ANSI Z535.5-2011 contain information regarding safety signs.

2. Shields or enclosures

Guards less than 100 mm (4 in) outside of the guard zone shall completely enclose the parts from contact up to the heights listed in column 2 of Table 124-1. They shall be not closer to the live parts than listed in column 4 of Table 124-1, except when suitable insulating material is used with circuits of less than 2500 V to ground. If more than 100 mm (4 in) outside the guard zone, the guards shall extend at least 2.60 m (8.5 ft) above the floor. Covers or guards, which must at any time be removed while the parts they guard are live, shall be so arranged that they cannot readily be brought into contact with live parts.

3. Supplemental barriers or guards within electric supply stations

If the vertical distance in Table 124-1 cannot be obtained, railings or fences may be used. Railings or fences, if used, shall be not less than 1.07 m (3.5 ft) high and shall be located at a horizontal distance of at least 900 mm (3 ft) [and preferably not more than 1.20 m (4 ft)] from the nearest point of the guard zone that is less than 2.60 m (8.5 ft) above the floor or grade (see Figure 124-2).

NOTE: It is preferred that the railing or fence be located as close as practical to the parts, while providing a sufficient clear distance to the side of the guard zone to allow appropriate working room with expected tools (such as hot sticks) and working methods—see Rules 125 and 441.

4. Mats

Mats of rubber or other suitable insulating material complying with ASTM D 178-01 (2010) may be used at switchboards, switches, or rotating machinery as supplementary protection.

5. Live parts below supporting surfaces for persons

The supporting surfaces for persons above live parts shall be without openings. Toe boards at least 150 mm (6 in) high and handrails shall be provided at all edges.

6. Insulating covering on conductors or parts

Conductors and parts may be considered as guarded by insulation if they have either of the following:

a. Insulation covering of a type and thickness suitable for the voltage and conditions under which they are expected to be operated, and if operating above 2500 V to ground, having metallic insulation shielding or semiconducting shield in combination with suitable metallic drainage that is grounded to an effective ground.

   EXCEPTION: Nonshielded insulated conductors listed by a qualified testing laboratory shall be permitted for use up to 8000 V (phase to phase) when the conductors meet the requirements of the NEC, Article 310-6.

b. Barriers or enclosures that are electrically and mechanically suitable for the conditions under which they are expected to be operated.

D. Taut-string distances

Vertical clearances to energized parts or parts of indeterminate potential as required by Rule 124A that are set back from the edge of equipment or other barriers to clear reaching distance may be composed of the vertical distance of the top of the equipment or barrier above the nearest permanent supporting surface (such as a step, foundation pad, etc.) plus the shortest diagonal or horizontal clearance from the edge of the top side of the equipment or barrier to the part with a vertical component of the taut string distance not less than 1.5 m (5 ft), as shown in Figure 124-3.

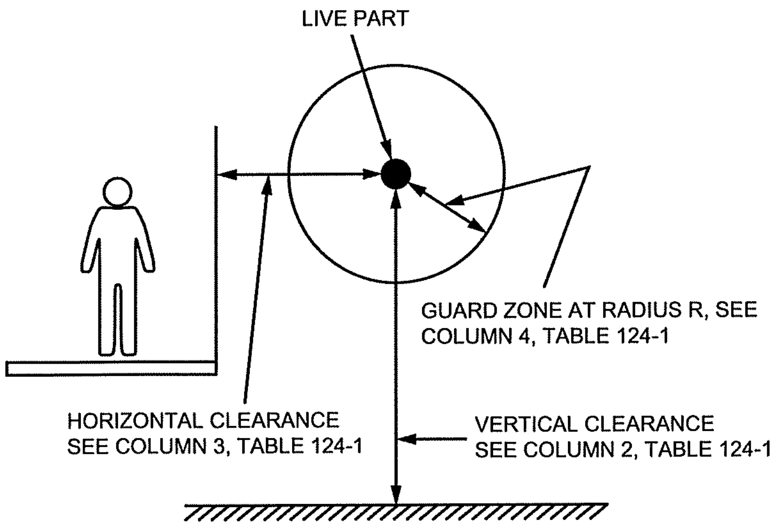


Figure 124-1—Clearance from live parts

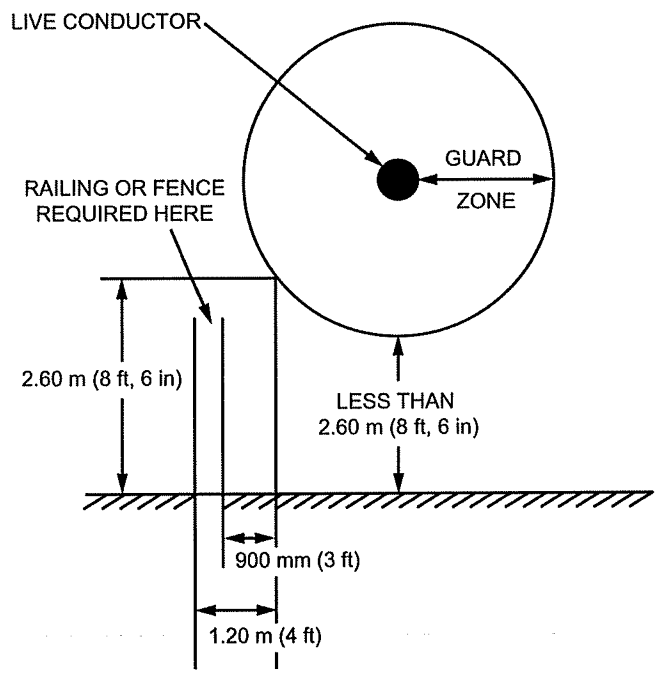


Figure 124-2—Railings or fences used as guards

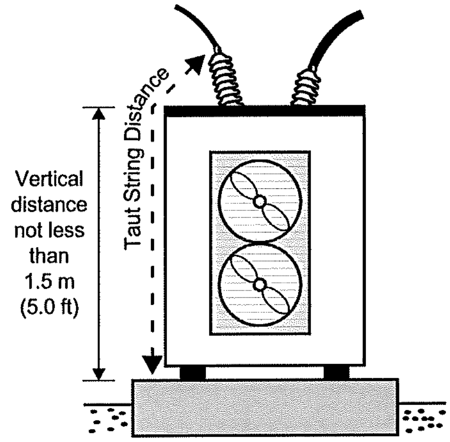


Figure 124-3—Taut-string measurement of vertical clearance to energized parts of equipment or behind barriers

m

Table 124-1—
Clearances from live parts
PART A—Low, medium, and high voltages (based on BIL factors)

Column 1	Column C	Column 2	Column 3	Column 4
Maximum design voltage between phases	Basic impulse insulation level (BIL) [5]	Vertical clearance of unguarded parts [1]	Horizontal clearance of unguarded parts [1]	Clearance guard to live parts [1]
kV	kV	m	m	mm
0.3	—	Not specified	Not specified	Not specified
0.6	—	2.64	1.02	50
2.4	—	2.67	1.02	76
7.2	95	2.69	1.02	101
15	95	2.69	1.02	101
15	110	2.74	1.07	152
25	125	2.77	1.09	177
25	150	2.82	1.14	228
35	200	2.90	1.22	304
48	250	3.00	1.32	406
72.5	250	3.00	1.32	406
72.5	350	3.18	1.50	584
121	350	3.18	1.50	584
121	550	3.53	1.85	939
145	350	3.18	1.50	584
145	550	3.53	1.85	939
145	650	3.71	2.03	1117
169	550	3.53	1.85	939
169	650	3.71	2.03	1117
169	750	3.91	2.24	1320
242	550	3.53	1.85	939
242	650	3.71	2.03	1117
242	750	3.91	2.24	1320
242	900	4.19	2.51	1600
242	1050	4.52	2.84	1930

m

Table 124-1—
Clearances from live parts
PART B—Extra-high voltages (based on switching-surge factors)[2]

Column 1	Column A	Column B	Column 2	Column 3	Column 4
Maximum design voltage between phases	Switching-surge factor per unit[3][4]	Switching surge line to ground[4]	Vertical clearance of unguarded parts[1]	Horizontal clearance of unguarded parts[1]	Clearance guard to live parts[1]
kV		kV	m	m	m
362	2.2 or below	650	4.7	3.0	2.13
362	2.3	680	4.9	3.2	2.30
362	2.4	709	5.0	3.4	2.45
362	2.5	739	5.2	3.6	2.60
362	2.6	768	5.4	3.7	2.80
362	2.7	798	5.6	3.9	3.0
362	2.8	828	5.8	4.1	3.2
362	2.9	857	6.0	4.3	3.4
362	3.0	887	6.1	4.5	3.6
550	1.8 or below	808	5.7	4.1	3.2
550	1.9	853	5.9	4.3	3.4
550	2.0	898	6.2	4.6	3.6
550	2.1	943	6.6	4.9	4.0
550	2.2	988	6.9	5.2	4.3
550	2.3	1033	7.2	5.5	4.6
550	2.4	1078	7.5	5.8	4.9
550	2.5	1123	7.9	6.2	5.3
550	2.6	1167	8.2	6.6	5.6
550	2.7	1212	8.6	7.0	6.0
800	1.5	980	6.8	5.1	4.2
800	1.6	1045	7.3	5.6	4.7
800	1.7	1110	7.8	6.1	5.2
800	1.8	1176	8.3	6.6	5.7
800	1.9	1241	8.8	7.2	6.2
800	2.0	1306	9.4	7.7	6.8
800	2.1	1372	10.0	8.3	7.4
800	2.2	1437	10.6	8.9	8.0
800	2.3	1502	11.2	9.5	8.6
800	2.4	1567	11.8	10.0	9.2

m

Table 124-1— Clearances from live parts PART C—Extra-high voltages (based on BIL factors)[2]

Column 1	Column C	Column 2	Column 3	Column 4
Maximum design voltage between phases	Basic impulse insulation level (BIL) [4] [5]	Vertical clearance of unguarded parts [1]	Horizontal clearance of unguarded parts [1]	Clearance guard to live parts [1]
kV	kV	m	m	m
362	1050	4.7	3.0	2.13
362	1300	5.2	3.6	2.60
550	1550	5.7	4.1	3.2
550	1800	6.2	4.6	3.6
800	2050	6.8	5.2	4.2

m

Table 124-1—
Clearances from live parts
PART D—High voltage direct current (based on transient overvoltage)

Column 1	Column A	Column B	Column 2	Column 3	Column 4
Maximum design voltage conductor to ground	Transient overvoltage per unit ④	Transient overvoltage line to grnd ④	Vertical clearance of unguarded parts ①	Horizontal clearance of unguarded parts ①	Clearance guard to live parts①
kV		kV	m	m	m
250	1.5 or below	375	3.81	2.13	1.22
250	1.6	400	3.89	2.22	1.30
250	1.7	425	3.97	2.30	1.38
250	1.8	450	4.05	2.38	1.46
400	1.5 or below	600	4.54	2.87	1.95
400	1.6	640	4.67	3.00	2.08
400	1.7	680	4.88	3.21	2.29
400	1.8	720	5.12	3.45	2.53
500	1.5 or below	750	5.29	3.62	2.70
500	1.6	800	5.60	3.92	3.01
500	1.7	850	5.96	4.29	3.37
500	1.8	900	6.35	4.67	3.76
600	1.5 or below	900	6.35	4.67	3.76
600	1.6	960	6.73	5.06	4.14
600	1.7	1020	7.13	5.45	4.54
600	1.8	1080	7.57	5.89	4.97
750	1.5 or below	1125	7.90	6.23	5.31
750	1.6	1200	8.44	6.76	5.85
750	1.7	1275	9.06	7.38	6.47
750	1.8	1350	9.72	8.04	7.13

① Interpolate for intermediate values. The clearances in column 4 of this table are solely for guidance in installing guards without definite engineering design and are not to be considered as a requirement for such engineering design. For example, the clearances in the tables above are not intended to refer to the clearances between live parts and the walls of the cells, compartments, or similar enclosing structures. They do not apply to the clearances between bus bars and supporting structures nor to clearances between the blade of a disconnecting switch and its base. However, where surge-protective devices are applied to protect the live parts, the vertical clearances, column 2 of Table 124-1 Part A may be reduced provided the clearance is not less than 2.6 m plus the electrical clearance between energized parts and ground as limited by the surge-protective devices.

②Clearances shall satisfy either switching-surge or BIL duty requirements, whichever are greater.

③Switching-surge factor—an expression of the maximum switching-surge crest voltage in terms of the maximum operating line-to-neutral crest voltage of the power system.

④The values of columns A, B, and C are power system design factors that shall correlate with selected clearances. Adequate data to support these design factors should be available.

⑤The selection of station BIL shall be coordinated with surge-protective devices when BIL is used to determine clearance. BIL—basic impulse insulation level—for definition and application, see IEEE Std C62.82.1-2010 and IEEE Std 1427-2006.

NOTE: The values are for altitudes of 1000 m (3300 ft) or less. For higher altitudes refer to Rule 124A1.

ft

Table 124-1— Clearances from live parts PART A—Low, medium, and high voltages (based on BIL factors)

Column 1	Column C	Column 2		Column 3		Column 4	
Maximum design voltage between phases	Basic impulse insulation level (BIL) ⑤	Vertical clearance of unguarded parts ①		Horizontal clearance of unguarded parts ①		Clearance guard to live parts ①	
kV	kV	ft	in	ft	in	ft	in
0.3	—	Not specified		Not specified		Not specified	
0.6	—	8	8	3	4	0	2
2.4	—	8	9	3	4	0	3
7.2	95	8	10	3	4	0	4
15	95	8	10	3	4	0	4
15	110	9	0	3	6	0	6
25	125	9	1	3	7	0	7
25	150	9	3	3	9	0	9
35	200	9	6	4	0	1	0
48	250	9	10	4	4	1	4
72.5	250	9	10	4	4	1	4
72.5	350	10	5	4	11	1	11
121	350	10	5	4	11	1	11
121	550	11	7	6	1	3	1
145	350	10	5	4	11	1	11
145	550	11	7	6	1	3	1
145	650	12	2	6	8	3	8
169	550	11	7	6	1	3	1
169	650	12	2	6	8	3	8
169	750	12	10	7	4	4	4
242	550	11	7	6	1	3	1
242	650	12	2	6	8	3	8
242	750	12	10	7	4	4	4
242	900	13	9	8	3	5	3
242	1050	14	10	9	4	6	4

ft

Table 124-1— Clearances from live parts PART B—Extra-high voltages (based on switching-surge factors)②

Column 1	Column A	Column B	Column 2		Column 3		Column 4	
Maximum design voltage between phases	Switching surge factor per unit ④	Switching surge line to ground ④	Vertical clearance of unguarded parts ①		Horizontal clearance of unguarded parts ①		Clearance guard to live parts ①	
kV		kv	ft	in	ft	in	ft	in
362	2.2 or below	650	15	6	10	0	7	0
362	2.3	680	16	0	10	6	7	6
362	2.4	709	16	6	11	0	8	0
362	2.5	739	17	2	11	8	8	8
362	2.6	768	17	9	12	3	9	3
362	2.7	798	18	4	12	10	9	10
362	2.8	828	18	11	13	5	10	5
362	2.9	857	19	7	14	1	11	1
362	3.0	887	20	2	14	8	11	8
550	1.8 or below	808	18	10	13	4	10	4
550	1.9	853	19	6	14	0	11	0
550	2.0	898	20	6	15	0	12	0
550	2.1	943	21	6	16	0	13	0
550	2.2	988	22	6	17	0	14	0
550	2.3	1033	23	7	18	1	15	1
550	2.4	1078	24	8	19	2	16	2
550	2.5	1123	25	10	20	4	17	4
550	2.6	1167	27	0	21	6	18	6
550	2.7	1212	28	4	22	10	19	10
800	1.5	980	22	4	16	10	13	10
800	1.6	1045	23	11	18	5	15	5
800	1.7	1110	25	6	20	0	17	1
800	1.8	1176	27	3	21	9	18	9
800	1.9	1241	29	0	23	6	20	6
800	2.0	1306	30	10	25	4	22	4
800	2.1	1372	32	9	27	3	24	3
800	2.2	1437	34	8	29	3	26	2
800	2.3	1502	36	9	31	3	28	3
800	2.4	1567	38	9	33	3	30	3

ft

Table 124-1—
Clearances from live parts
PART C—Extra-high voltages (based on BIL factors)②

Column 1	Column C	Column 2		Column 3		Column 4	
Maximum design voltage between phases	Basic impulse insulation level ⑤ (BIL)④	Vertical clearance of unguarded parts ①		Horizontal clearance of unguarded parts ①		Clearance guard to live parts ①	
kV	kV	ft	in	ft	in	ft	in
362	1050	15	6	10	0	7	0
362	1300	17	2	11	8	8	8
550	1550	18	10	13	4	10	4
550	1800	20	6	15	0	12	0
800	2050	22	5	16	11	13	11

ft

Table 124-1—
Clearances from live parts
PART D—High voltage direct current (based on transient overvoltage)

Column 1	Column A	Column B	Column 2		Column 3		Column 4	
Maximum design voltage conductor to ground	Transient overvoltage per unit ④	Transient overvoltage line to grnd ④	Vertical clearance of unguarded parts ①		Horizontal clearance of unguarded parts ①		Clearance guard to live parts ①	
kV		kV	ft	in	ft	in	ft	in
250	1.5 or below	375	12	6	7	0	4	0
250	1.6	400	12	9	7	3	4	3
250	1.7	425	13	0	7	7	4	6
250	1.8	450	13	3	7	10	4	9
400	1.5 or below	600	14	11	9	5	6	5
400	1.6	640	15	4	9	10	6	10
400	1.7	680	16	0	10	6	7	6
400	1.8	720	16	10	11	4	8	4
500	1.5 or below	750	17	4	11	11	8	10
500	1.6	800	18	4	12	10	9	11
500	1.7	850	19	7	14	1	11	1
500	1.8	900	20	10	15	4	12	4
600	1.5 or below	900	20	10	15	4	12	4
600	1.6	960	22	1	16	7	13	7
600	1.7	1020	23	5	17	11	14	11
600	1.8	1080	24	10	19	4	16	4
750	1.5 or below	1125	25	11	20	5	17	5
750	1.6	1200	27	8	22	2	19	2
750	1.7	1275	29	9	24	3	21	3
750	1.8	1350	31	11	26	5	23	5

① Interpolate for intermediate values. The clearances in column 4 of this table are solely for guidance in installing guards without definite engineering design and are not to be considered as a requirement for such engineering design. For example, the clearances in the tables above are not intended to refer to the clearances between live parts and the walls of the cells, compartments, or similar enclosing structures. They do not apply to the clearances between bus bars and supporting structures nor to clearances between the blade of a disconnecting switch and its base. However, where surge-protective devices are applied to protect the live parts, the vertical clearances, column 2 of Table 124-1 Part A may be reduced provided the clearance is not less than 8.5 ft plus the electrical clearance between energized parts and ground as limited by the surge-protective devices.

②Clearances shall satisfy either switching-surge or BIL duty requirements, whichever are greater.

③ Switching-surge factor—an expression of the maximum switching-surge crest voltage in terms of the maximum operating line-to-neutral crest voltage of the power system.

④ The values of columns A, B, and C are power system design factors that shall correlate with selected clearances. Adequate data to support these design factors should be available.

⑤ The selection of station BIL shall be coordinated with surge-protective devices when BIL is used to determine clearance. BIL—basic impulse insulation level—for definition and application, see IEEE Std C62.82.1-2010 and IEEE Std 1427-2006.

NOTE: The values are for altitudes of 1000 m (3300 ft) or less. For higher altitudes refer to Rule 124A1.

125. Working space about electric equipment

A. Working space (600 V or less)

Access and working space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment.

1. Clear spaces

Working space required by this section shall not be used for storage. When normally enclosed energized parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be guarded.

2. Access and entrance to working space

At least one entrance shall be provided to give access to the working space about electric equipment.

3. Working space

The working space in the direction of access to energized parts operating at 600 V or less that require examination, adjustment, servicing, or maintenance while energized shall be not less than indicated in Table 125-1. In addition to the dimensions shown in Table 125-1, the working space shall be not less than 750 mm (30 in) wide in front of the electric equipment. Distances shall be measured from the energized parts if such are exposed or from the enclosure front or opening if such are enclosed. Concrete, brick, or tile walls shall be considered grounded.

4. Headroom working space

The headroom of working spaces about switchboards or control centers shall be not less than 2.13 m (7 ft).

5. Front working space

In all cases where there are energized parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than 900 mm (3 ft).

Table 125-1—Working space

Voltage to ground	Clear distance					
	Condition 1		Condition 2		Condition 3	
	mm	ft	mm	ft	mm	ft
0–150	900	3	900	3	900	3
151–600	900	3	1070	3-1/2	1200	4

Where the *conditions* are as follows:

1. Exposed energized parts on one side and no energized or grounded parts on the other side of the working space, or exposed energized parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not over 300 V shall not be considered energized parts.
2. Exposed energized parts on one side and grounded parts on the other side.
3. Exposed energized parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

EXCEPTION: Working space shall not be required in back of assemblies, such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

B. Working space over 600 V

Working space shall be in accordance with Table 124-1.

NOTE: Consideration should be given to the minimum approach distances of Rule 441.

126. Equipment for work on energized parts

When it is necessary for personnel to move themselves, material, or tools within the guard zone of unguarded energized parts, protective equipment shall be provided.

This protective equipment shall be periodically inspected, tested, and kept in a safe condition. Protective equipment shall be rated for not less than the voltage involved. Refer to Section 3 for a list of specifications for equipment.

127. Classified locations

Electrical installations in classified areas shall meet the requirements of the NEC, Articles 500 through 517. Areas classified in accordance with NEC Article 500 shall comply with the requirements of that Article and A. through L. below. Areas classified with the optional Zone method in accordance with NEC Article 505 shall comply with the requirements of that article.

A. Coal-handling areas

1. Unventilated spaces inside or above coal-storage silos or bunkers, or other enclosed coal-storage and coal-handling spaces where methane may accumulate in explosive or ignitable mixtures as defined in Article 500-5 of the NEC, are Class I, Division 1, Group D locations. Electric equipment in other locations in which flammable gases or vapors may exist shall be in accordance with the NEC, Article 500-5, or the locations shall be adequately ventilated.

2. Adequate ventilation exists when the method of ventilation will limit the likelihood of accumulation of significant quantities of vapor-air concentrations from exceeding 25% of the lower flammable limit.

3. Tunnels beneath stockpiles or surge piles; spaces inside, above, or below coal-storage silos or bunkers; or other enclosed coal-storage or coal-handling spaces or areas shall be Class II, Group F, Division 1 or Division 2 locations as determined by the NEC.

4. Enclosed sections where only wet coal is handled, or enclosed sections so cut off as to be free from dangerous amounts of coal dust, are not classified. Coal shall be considered to be wet if enough water sprays are installed and maintained to limit the atmospheric concentration of total entrapped volatiles to 8% or less.

   NOTE: See ASTM D 3175-11 for coal and coke dusts [B21].

5. Locations having completely dust-tight pulverized fuel systems designed and installed in compliance with NFPA 8503-1997 shall not be considered classified.

6. Portable lamps for use in fuel bunkers or bins shall be suitable for Class II, Division 1 locations.

7. Sparking electric tools shall not be used where combustible dust or dust clouds are present.

8. An equipment grounding conductor shall be carried with the power conductors and serve to ground the frames of all equipment supplied from that circuit. The origin of the grounding conductor shall be:

   a. Ungrounded delta or wye-transformer frame ground.

   b. Grounded delta or wye-transformer grounded secondary connection.

   c. Resistance grounded wye—the grounded side of the grounding resistor.

9. Ungrounded systems should be equipped with a ground-fault indicating device to give both a visual and audible alarm upon the occurrence of a ground fault in the system.

B. Flammable and combustible liquids

1. Flammable liquid shall mean a liquid having a flash point below 38 °C (100 °F) and having a vapor pressure not exceeding 275 kPa (40 lb/in^2) (absolute) at 38 °C (100 °F) and shall be known as a Class I liquid.
2. Combustible liquid shall mean a liquid having a flash point greater than or equal to 38 °C (100 °F) and having a vapor pressure not exceeding 275 kPa (40 lb/in^2) (absolute) at 38 °C (100 °F).
3. Class I liquids are subdivided as follows:
    a. Class IA includes those having flash points below 23 °C (73 °F) and having a boiling point below 38 °C (100 °F).
    b. Class IB includes those having flash points below 23 °C (73 °F).
    c. Class IC includes those having flash points at or above 23 °C (73 °F) and below 38 °C (100 °F).
4. Combustible liquids are subdivided as follows:
    a. Class II includes those having flash points equal to or greater than 38 °C (100 °F) but less than 60 °C (140 °F).
    b. Class IIIA includes those having flash points equal to or greater than 60 °C (140 °F) but less than 93 °C (200 °F).
    c. Class IIIB includes those having flash points greater than or equal to 93 °C (200 °F).

C. Flammable liquid storage area

Electric wiring and equipment located in flammable liquid storage areas shall be installed in accordance with applicable sections of NFPA 30-2000 and the NEC.

D. Loading and unloading facilities for flammable and combustible liquids

Electric equipment located in the area shall be installed in accordance with applicable sections of NFPA 30-2000 and the NEC.

E. Gasoline-dispensing stations

Electric equipment installed in areas used for dispensing flammable liquids shall be installed in accordance with applicable sections of NFPA 30A-2000 and the NEC.

F. Boilers

When storing, handling, or burning fuel oils that have flash points below 38 °C (100 °F) the installation shall conform to NFPA 30-2000 and the NEC.

NOTE: Attention must be given to electrical installations in areas where flammable vapors or gases may be present in the atmosphere. Typical locations are burner areas, fuel-handling equipment areas, fuel-storage areas, pits, sumps, and low spots where fuel leakage or vapors may accumulate. The NEC, Article 500 provides for classifying such areas and defines requirements for electrical installations in the areas so classified. The burner front piping and equipment shall be designed and constructed to eliminate hazardous concentrations of flammable gases that exist continuously, intermittently, or periodically under normal operating conditions. Providing the burners are thoroughly purged before removal for cleaning, burner front maintenance operations will not cause hazardous concentrations of flammable vapors to exist frequently. With such provisions, the burner front is not normally classified more restrictively than Class I, Division 2.

G. Gaseous hydrogen systems for supply equipment

1. Outdoor storage areas shall not be located beneath electric power lines.
2. Safety considerations at specific storage areas.

    Electric equipment shall be suitable for Class I, Division 2 locations:

a. Within 4.6 m (15 ft) of outdoor storage spaces

b. Within adequately ventilated separate buildings or special rooms for storing hydrogen

c. Within 7.6 m (25 ft) of a hydrogen storage space in an adequately ventilated building used for other purposes

3. Space around elements of the generator hydrogen seal oil system shall not be considered classified for electrical installation except where external venting is not provided in the bearing drain system.

4. Spaces around the hydrogen piping system beyond the point where the hydrogen storage system connects to distribution piping shall not be considered classified for electrical installations, outside the boundaries established in Rules 127G2a and 127G2c.

H. Liquid hydrogen systems

1. Electric wiring and equipment located within 900 mm (3 ft) of a point where connections are regularly made and disconnected shall be in accordance with the NEC, Article 501, Class I, Group B, Division 1 locations.

2. Except as provided in Paragraph 1, electric wiring and equipment located within 7.6 m (25 ft) of a point where connections are regularly made and disconnected or within 7.6 m (25 ft) of a liquid hydrogen storage container, shall be in accordance with the NEC, Article 501, Class I, Group B, Division 2 locations. When equipment approved for Class I, Group B atmospheres is not commercially available, the equipment may be (1) purged or ventilated in accordance with NFPA 496-1998, (2) intrinsically safe, or (3) approved for Class I, Group C atmospheres. This requirement does not apply to electric equipment that is installed on mobile supply trucks or tank cars from which the storage container is filled.

I. Sulfur

1. Electric wiring and equipment located in areas where sulfur dust is in suspension in explosive or ignitable mixtures during normal operations shall be suitable for Class II, Division 1, Group G.

J. Oxygen

1. Bulk oxygen installations are not defined as classified locations.

K. Liquefied petroleum gas (LPG)

Electric equipment and wiring installed in areas used for handling, storage, or utilization of LPG shall be installed in accordance with applicable sections of NFPA 58-2001, NFPA 59-2001, and the NEC.

L. Natural gas (methane)

Electric equipment and wiring installed in areas used for handling, storage, or utilization of natural gas shall be installed in accordance with applicable sections of NFPA 59A-2001 and the NEC.

NOTE: NFPA 497M-1997 [B64] and API RP500, 7 January 1998 [B14] provide additional guidelines for classifying these areas.

128. Identification

Electric equipment and devices shall be identified for safe use and operation. The identification shall be as nearly uniform as practical throughout any one station. Identification marks shall not be placed on removable covers or doors that could be interchanged.

129. Mobile hydrogen equipment

Mobile hydrogen supply units being used to replenish a hydrogen system shall be bonded both to the grounding system and to the grounded parts of the hydrogen system.

Section 13. Rotating equipment

Rotating equipment includes generators, motors, motor generators, and rotary converters.

130. Speed control and stopping devices

A. Automatic overspeed trip device for prime movers

When harmful overspeed can occur, prime movers driving generating equipment shall be provided with automatic overspeed trip devices in addition to their governors.

B. Manual stopping devices

An operator-initiated stopping device shall be provided for any machine that drives an electric power generator or rotary uninterruptible power supply (motor-generator). The operator-initiated stopping device shall be accessible to the operator during normal operation. Manual controls to be used in emergency for machinery and electric equipment shall be located so as to provide protection to the operator in the event of such emergency.

C. Speed limit for motors

Machines of the following types shall be provided with speed-limiting devices unless their inherent characteristics or the load and the mechanical connection thereto are such as to safely limit the speed.

1. Separately excited dc motors
2. Series motors

D. Number 130D not used in this edition.

E. Adjustable-speed motors

Adjustable-speed motors, controlled by means of field regulation, shall, in addition to the provisions of Rule 130C, be so equipped and connected that the field cannot be weakened sufficiently to permit dangerous speed.

F. Protection of control circuits

Where speed-limiting or stopping devices and systems are electrically operated, the control circuits by which such devices are actuated shall be protected from mechanical damage. Such devices and systems should be of the automatic tripping type.

131. Motor control

All motors arranged such that an unexpected starting of the motor might create an exposure of personnel to injury shall have the motor control circuit designed to block unintended re-energization of the motor after a power supply interruption of a duration sufficient for moving equipment to become stationary. The motor control shall be such that an operator must take some action to restart the motor, or automatic restarting shall be preceded by warning signals and a time delay sufficient for personnel action to limit the likelihood of injury. This requirement does not apply to those motors with an emergency use and where the opening of the circuit may cause less safe conditions.

132. Number 132 not used in this edition.

133. Short-circuit protection

Means shall be provided to automatically disconnect an electric motor from the supply source in the event of high-magnitude short-circuit currents within the motor.

Section 14.
Storage batteries

140. General

The provisions of this section are intended to apply to all stationary installations of storage batteries. For operating precautions, see Part 4 of this Code.

Space shall be provided around batteries for safe inspection, maintenance, testing, and cell replacement and space left above the cells to allow for operation of lifting equipment when required, addition of water, and taking measurements.

141. Location

Storage batteries shall be located within a protective enclosure or area accessible only to qualified persons. A protective enclosure can be a battery room, control building, or a case, cage, or fence that will protect the contained equipment and limit the likelihood of inadvertent contact with energized parts.

142. Ventilation

The battery area shall be ventilated, either by a natural or powered ventilation system to limit hydrogen accumulation to less than an explosive mixture. Failure of a continuously operated or automatically controlled powered ventilation system required by design to limit hydrogen accumulation to less than an explosive mixture shall be annunciated.

143. Racks

Racks refer to frames designed to support cells or trays. Racks shall be firmly anchored, preferably to the floor. Anchoring to both walls and floors is not recommended. Racks made of metal shall be grounded.

144. Floors in battery areas

Floors of battery areas should be of an acid-resistive material, painted with acid-resistive paint, or otherwise protected. Provision should be made to contain spilled electrolyte.

145. Illumination for battery areas

Lighting fixtures shall be protected from physical damage by guards or isolation. Receptacles and lighting switches should be located outside of battery areas.

146. Service facilities

A. Proper eye protection and clothing shall be provided in the battery area during battery maintenance and installation and shall consist of the following:

1. Goggles or face shield
2. Acid-resistant gloves
3. Protective aprons and overshoes

4. Portable or stationary water facilities or neutralizing agent for rinsing eyes and skin

B. Safety signs inside and outside of a battery room or in the vicinity of a battery area, prohibiting smoking, sparks, or flame shall be provided.

NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, ANSI Z535.4-2011, and ANSI Z535.5-2011 contain information regarding safety signs.

Section 15.
Transformers and regulators

150. Current-transformer secondary circuits protection when exceeding 600 V

Secondary circuits, when in the vicinity of primary circuits exceeding 600 V should, except for short lead lengths at the terminals of the transformer, have the secondary wiring adequately protected by means of conduit, covering, or some other protection. Any metallic covering used shall be effectively grounded, giving appropriate consideration to circulating currents. Current transformers shall have provision for shorting the secondary winding.

151. Grounding secondary circuits of instrument transformers

The secondary circuits of instrument transformers shall be effectively grounded where functional requirements permit.

152. Location and arrangement of power transformers and regulators

A. Outdoor installations

1. Power transformers and regulators shall be so installed that all energized parts are enclosed or guarded so as to limit the likelihood of inadvertent contact, or the energized parts shall be physically isolated in accordance with Rule 124. The case shall be effectively grounded or guarded.

2. The installation of liquid-filled transformers shall utilize one or more of the following methods to minimize fire hazards. The method to be applied shall be according to the degree of the fire hazard. Recognized methods are the use of less flammable liquids, space separation, fire-resistant barriers, automatic extinguishing systems, absorption beds, and enclosures.

   The amount and characteristics of liquid contained should be considered in the selection of space separation, fire-resistant barriers, automatic extinguishing systems, absorption beds, and enclosures that confine the liquid of a ruptured transformer tank, all of which are recognized as safeguards.

B. Indoor installations

1. Transformers and regulators 75 kVA and above containing an appreciable amount of flammable liquid and located indoors shall be installed in ventilated rooms or vaults separated from the balance of the building by fire walls. Doorways to the interior of the building shall be equipped with fire doors and shall have means of containing the liquid.

2. Transformers or regulators of the dry type or containing a nonflammable liquid or gas may be installed in a building. When installed in a building used for other than station purposes, a case or an enclosure shall be so designed that all energized parts are enclosed in the case that is grounded in accordance with Rule 123. As an alternate, the entire unit may be enclosed so as to limit the likelihood of inadvertent contact by persons with any part of the case or wiring. When installed, the pressure-relief vent of a unit containing a nonbiodegradable liquid shall be furnished with a means for absorbing toxic gases.

3. Transformers containing less flammable liquid may be installed in a supply station building in such a way as to minimize fire hazards. The amount of liquid contained, the type of electrical protection, and tank venting shall be considered in the selection of space separation from combustible materials or structures, liquid confinement, fire-resistant barriers or enclosures, or extinguishing systems.

153. Short-circuit protection of power transformers

Power transformers shall be provided with means to disconnect automatically the source of supply of current for a high magnitude short circuit (fault) within the transformer.

The devices for automatically disconnecting the source of supply may be a circuit breaker, circuit switcher, fuse, thyristor blocking, or other reasonable methods either locally or remotely connected to the transformer. This includes disconnecting the generator electric field source together with the source of mechanical energy upon detection of a fault in either the generator step-up or station auxiliary transformer. Removing a single phase rather than all three phases to extinguish short-circuit current is acceptable.

EXCEPTION: Transformers other than power transformers are exempt from this rule. This includes instrument transformers, neutral grounding transformers, regulating transformers, and other transformers specifically for control, protection, or metering.

Section 17.
Circuit breakers, reclosers, switches, and fuses

170. Arrangement

Circuit breakers, reclosers, switches, and fuses shall be so installed as to be accessible only to persons qualified for operation and maintenance. Walls, barriers, latched doors, location, isolation, or other means shall be provided to protect persons from energized parts or arcing. Conspicuous markings (such as numbers/letters/symbols) shall be provided on each device and at any remote operating points so as to facilitate identification by employees authorized to operate the device. No device identification shall be duplicated within the same supply station. When the contact parts of a switching device are not normally visible, the device shall be equipped with an indicator to show all normal operating positions.

171. Application

Circuit breakers, circuit switchers, reclosers, switches, and fuses should be utilized with due regard to their assigned ratings of voltage and continuous and momentary currents. Devices that are intended to interrupt fault current shall be capable of safely interrupting the maximum short-circuit current they are intended to interrupt, and for the circumstances under which they are designed to operate. The interrupting capacity should be reviewed prior to each significant system change.

172. Circuit breakers, reclosers, and switches containing oil

Circuit-interrupting devices containing flammable liquids shall be adequately segregated from other equipment and buildings to limit damage in the event of an explosion or fire. Segregation may be provided by spacing, by fire-resistant barrier walls, or by metal cubicles. Gas-relief vents should be equipped with oil-separating devices or piped to a safe location. Means shall be provided to control oil that could be discharged from vents or by tank rupture. This may be accomplished by absorption beds, pits, drains, or by any combination thereof. Buildings or rooms housing this equipment shall be of fire-resistant construction.

173. Switches and disconnecting devices

A. Capacity

Switches shall be of suitable voltage and ampere rating for the circuit in which they are installed. Switches used to break load current shall be marked with the current that they are rated to interrupt.

B. Provisions for disconnecting

Switches and disconnectors shall be so arranged that they can be locked in the open and closed positions, or plainly tagged where it is not practical to install locks. (See Part 4 of this Code.) For devices that are operated remotely and automatically, the control circuit shall be provided with a positive disconnecting means near the apparatus to limit the likelihood of accidental operation of the mechanism.

174. Disconnection of fuses

Fuses in circuits of more than 150 V to ground or more than 60 A shall be classified as disconnecting fuses or be so arranged that before handling:

Section 18.
Switchgear and metal-enclosed bus

180. Switchgear assemblies

A. General requirements for all switchgear

1. To minimize movement, all switchgear shall be secured in a manner consistent with conditions of service and applicable manufacturer's instructions.
2. Cable routed to switchgear shall be supported to minimize forces applied to conductor terminals.
3. Piping containing liquids, or corrosive or hazardous gases, shall not be routed in the vicinity of switchgear unless suitable barriers are installed to protect the switchgear from damage in the event of a pipe failure.
4. Switchgear shall not be located where foreign flammable or corrosive gases or liquids routinely and normally are discharged. Companion equipment such as transformers and switchgear are not considered foreign.
5. Switchgear should not be installed in a location that is still specifically under active construction, especially where welding and burning are required directly overhead. Special precautions should be observed to minimize impingement of slag, metal filings, moisture, dust, or hot particles.

   EXCEPTION: Switchgear may be installed in a general construction area if suitable temporary protection is provided to minimize the risks associated with general construction activities.
6. Precautions shall be taken to protect energized switchgear from damage when maintenance is performed in the area.
7. Switchgear enclosure surfaces shall not be used as physical support for any item unless specifically designed for that purpose.
8. Enclosure interiors shall not be used as storage areas unless specifically designed for that purpose.
9. Metal instrument cases shall be grounded and enclosed in covers that are metal and grounded, or are of insulating material.

B. Metal-enclosed power switchgear

1. Switchgear shall not be located within 7.6 m (25 ft) horizontally indoors or 3.0 m (10 ft) outdoors of storage containers, vessels, utilization equipment, or devices containing flammable liquids or gases.

   EXCEPTION: If an intervening barrier, designed to mitigate the potential effects of flammable liquids or gases, is installed, the distances listed above do not apply.

   NOTE: Rule 180B1 is not intended to apply to the power transformer(s) supplying the switchgear.
2. Enclosed switchgear rooms shall have at least two means of egress, one at each extreme of the area, not necessarily in opposite walls. Doors shall swing out and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

   EXCEPTION: One door may be used when required by physical limitations if means are provided for unhampered exit during emergencies.
3. Space shall be maintained in front of switchgear to allow breakers to be removed and turned without obstruction.
4. Space shall be maintained in the rear of the switchgear to allow for door opening to at least 90 degrees open, or a minimum of 900 mm (3 ft) without obstruction when removable panels are used.
5. Permanently mounted devices, panelboards, etc., located on the walls shall not encroach on the space requirements in Rule 180B4.

6. Where columns extend into the room beyond the wall surface, the face of the column shall not encroach on the space requirements in Rule 180B4.
7. Low-voltage cables or conductors, except those to be connected to equipment within the compartments rated greater than 1000 V, shall not be routed through the divisions of switchgear unless installed in rigid metal conduit or isolated by rigid metal barriers.
8. Low-voltage conductors routed from sections rated greater than 1000 V of switchgear shall terminate in a low-voltage section before being routed external to the switchgear.
9. Conductors entering switchgear shall be insulated for the highest operating voltage in that compartment or be separated from insulated conductors of other voltage ratings.
10. Switchgear enclosures shall be suitable for the environment in which they are installed.
11. A safety sign shall be placed in each cubicle containing more than one source (greater than 1000 V).

    NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, ANSI Z535.4-2011, and ANSI Z535.5-2011 contain information regarding safety signs.

12. The location of control devices shall be readily accessible to personnel. Instruments, relays, and other devices requiring reading or adjustments should be so placed that work can readily be performed from the working space.

C. Dead-front power switchboards

Dead-front power switchboards with uninsulated rear connections shall be installed in rooms or spaces that are capable of being locked, with access limited to qualified personnel.

D. Motor control centers

1. Motor control centers shall not be connected to systems having higher short-circuit capability than the bus bracing can withstand. Where current-limiting fuses are employed on the source side of the bus, the bus bracing and breaker-interrupting rating are determined by the peak let-through characteristic of the current-limiting fuse.
2. A safety sign shall be placed in each cubicle containing more than one voltage source.

    NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, ANSI Z535.4-2011, and ANSI Z535.5-2011 contain information regarding safety signs.

E. Control switchboards

1. Cabinets containing solid-state logic devices, electron tubes, or relay logic devices such as boiler analog, burner safety, annunciators, computers, inverters, precipitator logic, soot blower control, load control, telemetering, totalizing microwave radio, etc., are covered under these rules.
2. Where carpeting is installed in rooms containing control switchboards, it shall be of an antistatic type and shall minimize the release of noxious, corrosive, caustic, or toxic gas under any condition.
3. Layout of the installation shall provide adequate clearance in front of, or rear of, panels if applicable, to allow meters to be read without use of stools or auxiliary devices.
4. Where personnel access to control panels, such as benchboards, is required, cables shall be routed through openings separate from the personnel opening. Removable, sliding, or hinged panels are to be installed to close the personnel opening when not in use.

181. Metal-enclosed bus

A. General requirements for all types of bus

1. Busways shall be installed only in accessible areas.

2. Busways, unless specifically approved for the purpose, shall not be installed: where subject to severe physical damage or corrosive vapors; in hoistways; in any classified hazardous location; outdoors or in damp locations.
3. Deadends of busway shall be closed.
4. Busways should be marked with the voltage and current rating for which they are designed, in such manner as to be visible after installation.

B. Isolated-phase bus

1. The minimum clearance between an isolated-phase bus and any magnetic material shall be the distance recommended by the manufacturer to avoid overheating of the magnetic material.
2. Nonmagnetic conduit should be used to protect the conductors for bus-alarm devices, thermocouples, space heaters, etc., if routed within the manufacturer's recommended minimum distance to magnetic material and parallel to isolated-phase bus enclosures.
3. When enclosure drains are provided for isolated-phase bus, necessary piping shall be provided to divert water away from electrical equipment.
4. Wall plates for isolated-phase bus shall be nonmagnetic, such as aluminum or stainless steel.
5. Grounding conductors for isolated-phase bus accessories should not be routed through ferrous conduit.

Section 19.
Surge arresters

190. General requirements

If arresters are required, they shall be located as close as practical to the equipment they protect.

NOTE: See IEEE Std C62.1™-1989 [B58] and IEEE Std C62.11™-1999 [B59] for additional information.

191. Indoor locations

Arresters, if installed inside of buildings, shall be enclosed or shall be located well away from passageways and combustible parts.

192. Grounding conductors

Grounding conductors shall be run as directly as practical between the arresters and ground and be of low impedance and ample current-carrying capacity and shall be grounded in accordance with the methods outlined in Section 9.

193. Installation

Arresters shall be installed in such a manner and location that neither the expulsion of gases nor the arrester disconnector is directed upon live parts in the vicinity.

Part 2.
Safety Rules for the Installation and Maintenance of Overhead Electric Supply and Communication Lines

Section 20.
Purpose, scope, and application of rules

200. Purpose

The purpose of Part 2 of this Code is the practical safeguarding of persons during the installation, operation, or maintenance of overhead supply and communication lines and their associated equipment.

201. Scope

Part 2 of this Code covers supply and communication conductors and equipment in overhead lines. It covers the associated structural arrangements of such systems and the extension of such systems into buildings. The rules include requirements for spacing, clearances, and strength of construction. They do not cover installations in electric supply stations except as required by Rule 162A.

NOTE 1: Part 4 contains the approach distances and work rules required of supply and communication employers and their employees working on or near supply and communication lines and equipment.

NOTE 2: The approach distances to energized parts, and other requirements applicable to the activities of utility or non-utility construction personnel, and others in close proximity to existing supply lines are governed by the Occupational Health and Safety Administration (OSHA), federal, state, or local statutes or regulations.

202. Application of rules

The general requirements for application of these rules are contained in Rule 13. However, when a supporting structure is replaced, the arrangement of equipment shall confirm to the current edition of Rule 238C.

Section 21. General requirements

210. Referenced sections

The Introduction (Section 1), Definitions (Section 2), References (Section 3), and Grounding methods (Section 9) shall apply to the requirements of Part 2.

211. Number 211 not used in this edition.

212. Induced voltages

Rules covering supply-line influence and communication-line susceptiveness have not been detailed in this Code. Cooperative procedures are recommended in the control of voltages induced from proximate facilities. Therefore, reasonable advance notice should be given to owners or operators of other proximate facilities that may be adversely affected by new construction or changes in existing facilities.

NOTE: Additional information about supply-line influence and communication-line susceptiveness may be obtained from IEEE Std 776™-1992 [B39] and IEEE Std 1137™-1991 [B51].

213. Accessibility

All parts that must be examined or adjusted during operation shall be arranged so as to be accessible to authorized persons by the provision of adequate climbing spaces, working spaces, working facilities, and clearances between conductors.

214. Inspection and tests of lines and equipment

A. When in service

1. Initial compliance with rules

   Lines and equipment shall comply with these safety rules when placed in service.

2. Inspection

   Lines and equipment shall be inspected at such intervals as experience has shown to be necessary.

   NOTE: It is recognized that inspections may be performed in a separate operation or while performing other duties, as desired.

3. Tests

   When considered necessary, lines and equipment shall be subjected to practical tests to determine required maintenance.

4. Inspection records

   Any conditions or defects affecting compliance with this Code revealed by inspection or tests, if not promptly corrected, shall be recorded; such records shall be maintained until the conditions or defects are corrected.

5. Corrections

   a. Lines and equipment with recorded conditions or defects that would reasonably be expected to endanger human life or property shall be promptly corrected, disconnected, or isolated.

b. Other conditions or defects shall be designated for correction.

B. When out of service

1. Lines infrequently used

Lines and equipment infrequently used shall be inspected or tested as necessary before being placed into service.

2. Lines temporarily out of service

Lines and equipment temporarily out of service shall be maintained in a safe condition.

3. Lines permanently abandoned

Lines and equipment permanently abandoned shall be removed or maintained in a safe condition.

215. Grounding of circuits, supporting structures, and equipment

A. Methods

Grounding required by these rules shall be in accordance with the applicable methods given in Section 9.

B. Circuits

1. Common neutral

A conductor used as a common neutral for primary and secondary circuits shall be effectively grounded.

2. Other neutrals

Primary line, secondary line, and service neutral conductors shall be effectively grounded.

EXCEPTION 1: Circuits designed for ground-fault detection and impedance-current-limiting devices.

EXCEPTION 2: Primary circuits designed with a single point grounded neutral. This type of neutral conductor is not an effectively grounded neutral conductor.

3. Other conductors

Line or service conductors, other than neutral conductors, that are intentionally grounded, shall be effectively grounded.

4. Surge arresters

Where the operation of surge arresters is dependent upon grounding, they shall be effectively grounded.

5. Use of earth as part of circuit

a. Supply circuits shall not be designed to use the earth normally as the sole conductor for any part of the circuit.

b. Monopolar operation of a bipolar HVDC system is permissible for emergencies and limited periods for maintenance.

C. Non-current-carrying parts

1. General

Metal or metal-reinforced supporting structures, including lamp posts; metal conduits and raceways; cable sheaths; messengers; metal frames, cases, and hangers of equipment; and metal switch handles and operating rods shall be effectively grounded. For the purpose of this rule metallic stand-off brackets or straps, metal crossarm braces, metal through-bolts, etc., are not considered to be metal frames, cases, or hangers of equipment and therefore not required to be effectively grounded.

For the purpose of this rule, a wood structure with metal-reinforcing trusses installed at its base for strength purposes is not considered to be a metal-reinforced structure and therefore not required to be effectively grounded.

EXCEPTION 1: This rule does not apply where both (a) and (b) are met:

(a) Frames, cases, and hangers of equipment; and switch handles and operating rods that are:

1. 2.45 m (8 ft) or more above readily accessible surfaces, or
2. Are otherwise isolated or guarded.

(b) The practice of not grounding such items has been a uniform practice over a well-defined operating area.

If the decision is made to ground new items located in the supply space, the rules do not require retrofitting existing ungrounded items.

NOTE: Typical practice is to ground existing items whenever significant work is done on existing structures.

EXCEPTION 2: This rule does not apply to isolated or guarded equipment cases in certain specialized applications, such as series capacitors where it is necessary that equipment cases be either ungrounded or connected to the circuit. Such equipment cases shall be considered as energized and shall be suitably identified.

EXCEPTION 3: This rule does not apply to equipment cases, frames, equipment hangers, conduits, messengers, raceways, and cable sheaths enclosing or supporting only communication conductors, provided they are not exposed to contact with open supply conductors.

2. Guys

a. Anchor guys

Anchor guys shall be effectively grounded as specified in Rule 092C2.

EXCEPTION: Anchor guys are not required to be effectively grounded where one or more guy insulators are inserted in the anchor guy and both of the following are met:

(1) Guy insulators shall meet the requirements of Rule 279A and

(2) Guy insulators shall be positioned so as to limit the likelihood of any portion of an anchor guy becoming energized within 2.45 m (8 ft) of the ground level in the event that the anchor guy becomes slack or breaks.

b. Span guys

Span guys shall be effectively grounded as specified in Rule 092C2.

EXCEPTION: Span guys are not required to be effectively grounded where one or more guy insulators are inserted in the span guy and both of the following are met:

(1) Guy insulators shall meet the requirements of Rule 279A and

(2) Guy insulators shall be positioned so as to limit the likelihood of any portion of a span guy, becoming energized within 2.45 m (8 ft) of the ground level in the event that the span guy becomes slack.

NOTE 1: For the purpose of Rule 215C2, if a span guy and its associated anchor guy are bonded together, they may be considered as one guy.

NOTE 2: Nothing in Rule 215C2 limits a portion(s) of a guy from being insulated and another portion(s) being effectively grounded.

3. Span wires

a. Supporting luminaires or traffic signals

Span wires supporting luminaires or traffic signals shall be effectively grounded.

EXCEPTION: Span wires are not required to be effectively grounded where one or more guy insulators are inserted in the span wire and both of the following are met:

(1) Span-wire insulators shall meet the requirements of Rule 279B and

(2) Insulator(s) shall be positioned so as to limit the likelihood of any portion of a span wire becoming energized within 2.45 m (8 ft) of the ground level in the event that the span wire becomes slack.

b. Supporting energized trolley or electric railroad contact conductors

(1) All span wires supporting energized trolley or electric railroad contact conductors, including bracket span wires, shall have a suitable insulator (in addition to an insulated hanger if used) inserted between each point of support of the span wire and the trolley or electric railroad contact conductor supported.

EXCEPTION 1: Single insulators, as provided by an insulated hanger, may be permitted when the span wire or bracket is supported on wood poles supporting only trolley, railway feeder, or communication conductors used in the operation of the railway concerned.

EXCEPTION 2: Insulators are not required if the span wire is effectively grounded.

EXCEPTION 3: This rule does not apply to insulated feeder taps used as span wires.

(2) In case insulated hangers are not used, the insulator shall be located so as to limit the likelihood of having the energized part of the span wire within 2.45 m (8 ft) of the ground level in the event of a broken wire.

NOTE: Nothing in Rule 215C3 limits a portion(s) of a span wire from being insulated and another portion(s) being effectively grounded.

4. Insulators used to limit galvanic corrosion

An insulator in the guy strand used exclusively for the limitation of galvanic corrosion of metal in ground rods, anchors, anchor rods, or pipe in an effectively grounded system shall meet the requirements of Rule 279A1c and shall be installed such that (a) the upper portion of a guy has been effectively grounded according to Rule 215C2a, and (b) the top of insulators used to limit galvanic corrosion shall be installed at an elevation below exposed energized conductors and parts.

NOTE: See Rule 279A2a.

5. Multiple messengers on the same structure

Communication cable messengers exposed to power contacts, power induction, or lightning, shall be bonded together at intervals specified in Rule 092C1.

216. Arrangement of switches

A. Accessibility

Switches or their control mechanisms shall be installed so as to be accessible to authorized persons.

B. Indicating open or closed position

Switch position shall be visible or clearly indicated.

C. Locking

Switch-operating mechanisms that are accessible to unauthorized persons shall have provisions for locking in each operational position and shall be locked or otherwise secured except during operation or testing.

NOTE: See Rule 444C.

D. Uniform position

The handles or control mechanisms for all switches throughout any system should have consistent positions when opened and uniformly different positions when closed in order to minimize operating errors. Where this practice is not followed, the switches should be marked to minimize mistakes in operation.

E. Remotely controlled, automatic transmission, or distribution overhead line switching devices shall have local provisions to render remote or automatic controls inoperable.

217. General

A. Supporting structures

1. Protection of structures

a. Mechanical damage

Appropriate physical protection shall be provided for supporting structures in parking lots, in alleys, or next to driveways subject to vehicular traffic abrasion that would materially affect their strength.

This rule does not require protection or marking of structural components located outside of the traveled ways of roadways or established parking areas.

NOTE: Experience has shown that it is not practical to protect structures from contact by out-of-control vehicles operating outside of established traveled ways. See Rule 231B for structure clearances to roadways.

b. Fire

Supporting structures shall be placed and maintained so as to be exposed as little as is practical to brush, grass, rubbish, or building fires.

c. Attached to bridges

Supporting structures attached to bridges for the purpose of carrying open supply conductors exceeding 600 V shall be posted with appropriate safety signs.

NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, and ANSI Z535.4-2011 contain information regarding safety signs. ANSI Z535.3-2011 contains information regarding safety symbols to be used in place of a safety word message.

2. Readily climbable supporting structures

a. Readily climbable supporting structures, such as closely latticed poles, towers, or bridge attachments, carrying open supply conductors, which are adjacent to roads, regularly traveled pedestrian thoroughfares, or places where persons frequently gather (such as schools or public playgrounds), shall be equipped with barriers to inhibit climbing by unauthorized persons or posted with appropriate safety signs.

EXCEPTION: This rule does not apply where access to the supporting structure is limited by a fence meeting the height requirements of Rule 110A1.

NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, and ANSI Z535.4-2011 contain information regarding safety signs. ANSI Z535.3-2011 contains information regarding safety symbols to be used in place of a safety word message.

b. Steps

Steps permanently installed on supporting structures shall be not less than 2.45 m (8 ft) from the ground or other accessible surface.

Where steps are temporarily installed less than 2.45 m (8 ft) from the ground or other accessible surface, structures shall be attended or barriers to inhibit climbing by unauthorized persons shall be installed.

EXCEPTION 1: This rule does not apply where supporting structures are isolated.

EXCEPTION 2: This rule does not apply where access to the supporting structure is limited by a fence meeting the height requirements of Rule 110A1.

c. Standoff brackets

Standoff brackets on supporting structures shall be arranged so that there is not less than 2.45 m (8 ft) between either:

(1) The lowest bracket and ground or other accessible surface, or

(2) The two lowest brackets.

EXCEPTION: This rule does not apply where supporting structures are isolated.

3. Identification

   Supporting structures, including those on bridges, on which supply or communication conductors are maintained shall be so constructed, located, marked, or numbered so as to facilitate identification by employees authorized to work thereon.

4. Attachments, decorations, and obstructions

   No attachment of any kind to a supporting structure of a utility line (including lighting and metering structures) shall be allowed without the concurrence of the structure owner. Non-utility attachments shall also have concurrence of the occupant(s) of the space in which the attachment is made.

   a. No attachment shall cause any portion of the resulting installation to be in noncompliance with the clearance, grounding, strength, or other requirements of the NESC.

   b. Attachments shall neither obstruct the climbing space nor present a climbing hazard to utility personnel. Through-bolts shall be properly trimmed. Vines, nails, tacks, or other items which may interfere with climbing should be removed before climbing.

B. Unusual conductor supports

Where line conductors are attached to structures other than those used solely or principally for their support, all rules shall be complied with as far as they apply. Such additional precautions as may be deemed necessary by the administrative authority shall be taken to avoid damage to the structures or injury to the persons using them. The supporting of conductors on trees and roofs should be avoided.

C. Protection and marking of guys

1. The ground end of anchor guys exposed to pedestrian traffic shall be provided with a substantial and conspicuous marker.

   NOTE: There is no intent to require markers at all anchor guy locations.

2. Where an anchor is located in an established parking area, the guy shall either be protected from vehicle contact or marked.

   This rule does not require protection or marking of anchor guys located outside of the traveled ways of roadways or established parking areas.

   NOTE: Experience has shown that it is not practical to protect guys from contact by out of control vehicles operating outside of established traveled ways. See Rule 231B for clearances of structures adjacent to roadways.

NOTE: Visibility of markers can be improved by the use of color or color patterns that provide contrast with the surroundings.

218. Vegetation management

A. General

1. Vegetation management should be performed around supply and communication lines as experience has shown to be necessary. Vegetation that may damage ungrounded supply conductors should be pruned or removed.

   NOTE 1: Factors to consider in determining the extent of vegetation management required include, but are not limited to: line voltage class, species' growth rates and failure characteristics, right-of-way limitations, the vegetation's location in relation to the conductors, the potential combined movement of vegetation and conductors during routine winds, and sagging of conductors due to elevated temperatures or icing.

   NOTE 2: It is not practical to prevent all tree-conductor contacts on overhead lines.

2. Where pruning or removal is not practical, the conductor should be separated from the tree with suitable materials or devices to avoid conductor damage by abrasion and grounding of the circuit through the tree.

B. At line crossings, railroad crossings, limited-access highway crossings, or navigable waterways requiring crossing permits

The crossing span and the adjoining span on each side of the crossing should be kept free from overhanging or decayed trees or limbs that otherwise might fall into the line.

Section 22.
Relations between various classes of lines and equipment

220. Relative levels

A. Standardization of levels

The levels at which different classes of conductors are to be located should be standardized by agreement of the utilities concerned.

B. Relative levels: supply and communication conductors and equipment

1. Preferred levels

Supply conductors/cables or equipment should be carried at the higher level, where practical.

EXCEPTION: This rule does not apply to any of the following:

(a) Trolley feeders located for convenience approximately at the level of the trolley-contact conductor,

(b) Antennas located in the supply space or a communication space, in accordance with clearances required by Rule 235 and Rule 238,

(c) Effectively grounded switch handles and equipment cases (such as fire alarm boxes, control boxes, communication terminals, meters, or similar equipment cases, which may be mounted at a lower level in accordance with Footnote 7 of Table 232-2), or

(d) Communication cables located within a supply space in accordance with clearances required by Rule 235.

2. Special construction for railroad supply circuits of 600 V or less and carrying power not in excess of 5 kW associated with railroad communication circuits.

Where all circuits are owned or operated by one party or where cooperative consideration determines that the circumstances warrant and the necessary coordinating methods are employed, single-phase ac or two-wire dc circuits carrying a voltage of 600 V or less between conductors, with transmitted power not in excess of 5 kW, where located on structures with communication circuits, may be installed in accordance with Footnote 1 of Table 235-5, under the following conditions:

a. That such supply circuits are of covered conductor not smaller than AWG No. 8 medium hard-drawn copper or its equivalent in strength, and the construction otherwise conforms with the requirements for supply circuits of the same class.

b. That the supply circuits be placed on the end and adjacent pins of the lowest through signal support arm and that a 750 mm (30 in) climbing space be maintained from the ground up to a point at least 600 mm (24 in) above the supply circuits. The supply circuits shall be rendered conspicuous by the use of insulators of different form or color from others on the pole line or by stenciling the voltage on each side of the support arm between the pins carrying each supply circuit, or by indicating the voltage by means of metal characters.

c. That there shall be a vertical clearance of not less than 600 mm (2 ft) between the support arm carrying these supply circuits and the next support arm above. The other pins on the support arm carrying the supply circuits may be occupied by communication circuits used in the operation or control of signal system or other supply system if owned, operated, and maintained by the same company operating the supply circuits.

d. That such supply circuits shall be equipped with arresters and fuses installed in the supply end of the circuit and where the signal circuit is ac, the protection shall be installed on the secondary side of the supply transformer. The arresters shall be designed so as to break down at approximately twice the voltage between the wires of the circuit, but the breakdown voltage of the arrester need not be less than 1 kV. The fuses shall have a rating not in excess of approximately twice the maximum operating current of the circuit, but their rating need not be less than 10 A. The fuses likewise in all cases shall have a rating of at least 600 V, and where the supply transformer is a step-down transformer, shall be capable of opening the circuit successfully in the event the transformer primary voltage is impressed upon them.

e. Such supply circuits in cable meeting the requirements of Rule 230C1, 230C2, or 230C3 may be installed below communication attachments, with not less than 400 mm (16 in) vertical separation between the supply cable and the lowest communication attachment. Communication circuits other than those used in connection with the operation of the supply circuits shall not be carried in the same cable with such supply circuits.

f. Where such supply conductors are carried below communication conductors, transformers and other apparatus associated therewith shall be attached only to the sides of the support arm in the space between and at no higher level than such supply wires.

g. Lateral runs of such supply circuits carried in a position below the communication space shall be protected through the climbing space by wood molding or equivalent covering, or shall be carried in insulated multiple-conductor cable, and such lateral runs shall be placed on the underside of the support arm.

C. Relative levels: Supply lines of different voltage classifications (0 to 750 V, over 750 V to 8.7 kV, over 8.7 kV to 22 kV, over 22 kV to 50 kV, and over 50 kV)

1. At crossings or conflicts

Where supply conductors of different voltage classifications cross each other or structure conflict exists, the higher-voltage lines should be carried at the higher level.

2. On structures used only by supply conductors

Where supply conductors of different voltage classifications are on the same structures, relative levels should be as follows:

a. Where all circuits are owned by one utility, the conductors of higher voltage should be placed above those of lower voltage.

b. Where different circuits are owned by separate utilities, the circuits of each utility may be grouped together, and one group of circuits may be placed above the other group provided that the circuits in each group are located so that those of higher voltage are at the higher levels and that horizontal and vertical clearances of not less than those required by Rule 235 are maintained between the nearest line conductors of the respective utilities.

D. Identification of overhead conductors and cables

All conductors and cables of electric supply and communication lines should, as far as is practical, be arranged to occupy uniform positions throughout, or shall be constructed, located, marked, numbered, or attached to distinctive insulators or crossarms, so as to facilitate identification by employees authorized to work thereon. This does not prohibit systematic transposition of conductors.

E. Identification of equipment on supporting structures

All equipment of electric supply and communication lines should be arranged to occupy uniform positions throughout or shall be constructed, located, marked, or numbered so as to facilitate identification by employees authorized to work thereon.

221. Avoidance of conflict

Two separate lines, either of which carries supply conductors, should be so separated from each other that neither line conflicts with the other.

EXCEPTION: If elimination of conflict is not practical, the conflicting line or lines should be separated as far as practical and shall be built to the grade of construction required by Section 24 for a conflicting line, or the two lines shall be combined on the same structures.

222. Joint use of structures

Where the practice of joint use is mutually agreed upon by the affected utilities, facilities shall be subject to the appropriate grade of construction specified in Section 24. Joint use of structures should be considered for circuits along highways, roads, streets, and alleys. The choice between joint use of structures and separate lines shall be determined through cooperative consideration with other joint users of all the factors involved, including the character of circuits, worker safety, the total number and weight of conductors, tree conditions, number and location of branches and service drops, structure conflicts, availability of right-of-way, etc.

223. Communications protective requirements

A. Where required

Where communication apparatus is handled by other than qualified persons, it shall be protected by one or more of the means listed in Rule 223B if such apparatus is permanently connected to lines subject to any of the following:

1. Lightning
2. Contact with supply conductors whose voltage to ground exceeds 300 V
3. Transient rise in ground potential exceeding 300 V
4. Steady-state induced voltage of a hazardous level

Where communication cables will be in the vicinity of supply stations where large ground currents may flow, the effect of these currents on communication circuits should be evaluated.

NOTE: Additional information may be obtained from IEEE Std 487™-2007 [B34] and IEEE Std 1590™-2003 [B55].

B. Means of protection

Where communication apparatus is required to be protected under Rule 223A, protective means adequate to withstand the voltage expected to be impressed shall be provided by insulation, protected where necessary by surge arresters used in conjunction with fusible elements. Severe conditions may require the use of additional devices such as auxiliary arresters, drainage coils, neutralizing transformers, or isolating devices.

224. Communication circuits located within the supply space and supply circuits located within the communication space

A. Communication circuits located in the supply space

1. Communication circuits located in the supply space shall be installed and maintained only by personnel authorized and qualified to work in the supply space in accordance with the applicable rules of Sections 42 and 44.
2. Communication circuits located in the supply space shall meet the following clearance requirements, as applicable:
   a. Insulated communication cables supported by an effectively grounded messenger shall have the same clearances as neutrals meeting Rule 230E1 from communication circuits located in the communication space and from supply conductors located in the supply space. See Rules 235 and 238.
   b. Fiber-optic cables located in the supply space shall meet the requirements of Rule 230F.

c. Open-wire communication circuits permitted by other rules to be in the supply space shall have the same clearances from communication circuits located in the communication space and from other circuits located in the supply space as required by Rule 235 for ungrounded open supply conductors of 0 to 750 V.

EXCEPTION: Service drops meeting Rules 224A3a and 224A3b may originate in the supply space on a line structure or in the span and terminate in the communication space on the building or structure being served.

3. Communication circuits located in the supply space in one portion of the system may be located in the communication space in another portion of the system if the following requirements are met:

a. Where the communication circuit is, at any point, located above an energized supply conductor or cable, the communication circuit shall be protected by fuseless surge arresters, drainage coils, or other suitable devices to limit the normal communication circuit voltage to 400 V or less to ground.

NOTE: The grades of construction for communication conductors with inverted levels apply.

b. Where the communication circuit is always located below the supply conductors, the communication protection shall meet the requirements of Rule 223.

c. The transition(s) between the supply space and the communication space shall occur on a single structure; no transition shall occur between line structures.

EXCEPTION: Service drops meeting Rules 224A3a and 224A3b may originate in the supply space on a line structure or in the span and terminate in the communication space on the building or structure being served.

d. The construction and protection shall be consistently followed throughout the extent of such section of the communications system.

B. Supply circuits used exclusively in the operation of communication circuits

Circuits used for supplying power solely to apparatus forming part of a communications system shall be installed as follows:

1. Open-wire circuits shall have the grades of construction, clearances, insulation, etc., prescribed elsewhere in these rules for supply or communication circuits of the voltage concerned.

2. Special circuits operating at voltages in excess of 90 V ac or 150 V dc and used for supplying power solely to communications equipment may be included in communication cables under the following conditions:

a. Such cables shall have a conductive sheath or shield that is effectively grounded.

b. All circuits in such cables shall be owned or operated by one party and shall be maintained only by qualified personnel.

c. Supply circuits included in such cables shall be terminated at points accessible only to qualified personnel.

d. Communication circuits brought out of such cables, if they do not terminate in a repeater station or terminal office, shall be protected or arranged so that in the event of failure within the cable, the voltage on the communication circuit will not exceed 400 V to ground.

e. Terminal apparatus for the power supply shall be so arranged that the live parts are inaccessible when such supply circuits are energized.

EXCEPTION: The requirements of Rule 224B2 do not apply to communication circuits where the transmitted power does not exceed 150 W.

225. Electric railway construction

A. Trolley-contact conductor fastenings

All overhead trolley-contact conductors shall be supported and arranged so that the breaking of a single contact conductor fastening will not allow the trolley conductor live span wire, or current-carrying connection, to come within 3.0 m (10 ft) (measured vertically) from the ground, or from any platform accessible to the general public.

Span-wire insulation for trolley-contact conductors shall comply with Rule 279B.

B. High-voltage contact conductors

Trolley-contact conductors energized at more than 750 V shall be suspended in such a way that, if broken at one point, the conductor will not come within 3.6 m (12 ft) (measured vertically) of the ground, or any platform accessible to the public.

C. Third rails

Third rails shall be protected by adequate guards composed of wood or other suitable insulating material.

EXCEPTION: This rule does not apply where third rails are on fenced right-of-way.

D. Prevention of loss of contact at railroad crossings at grade

At crossings at grade with other railroads or other electrified railway systems, contact conductors shall be arranged as set forth in the following specifications 1, 2, 3, 4, and 5, following whichever apply:

1. Where the crossing span exceeds 30 m (100 ft), catenary construction shall be used for overhead trolley-contact conductors.
2. When pole trolleys, using either wheels or sliding shoes, are used:
   a. The trolley-contact conductor shall be provided with live trolley guards of suitable construction; or
   b. The trolley-contact conductor should be at a uniform height above its own track throughout the crossing span and the next adjoining spans. Where it is not practical to maintain a uniform height, the change in height shall be made in a gradual manner.

   EXCEPTION: Rule 225D2 does not apply where the crossing is protected by signals or interlocking.
3. When collectors of the pantograph type are used, the contact conductor and track through the crossing should be maintained in a condition where the rocking of pantograph-equipped cars or locomotives will not de-wire the pantograph. If this cannot be done, auxiliary contact conductors shall be installed. Wire height shall conform with Rule 225D2.
4. Where two electrified tracks cross:
   a. When the trolley-contact conductors are energized from different supply circuits, or from different phases of the same circuit, the trolley-conductor crossover shall be designed to insulate both conductors from each other. The design shall not permit either trolley collector to contact any conductor or part energized at a different voltage than at which it is designed to operate.
   b. Trolley-contact crossovers used to insulate trolley conductors of the same voltage but of different circuit sections shall be designed to limit the likelihood of both sections being simultaneously contacted by the trolley collector.
5. When third rail construction is used, and the length of the third rail gap at the crossings is such that a car or locomotive stopping on the crossing can lose propulsion power, the crossing shall be protected by signals or interlocking.

E. Guards under bridges

Trolley guards of suitable construction shall be provided where the trolley-contact conductor is so located that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

Section 23.
Clearances

230. General

A. Application

This section covers all clearances, including climbing spaces, involving overhead supply and communication lines.

NOTE: The more than 70 years of historical development and specification of clearances in Rules 232, 233, and 234 were reviewed for consistency among themselves and with modern practice and were appropriately revised in both concept and content for the 1990 Edition. See Appendix A.

1. Permanent and temporary installations

The clearances of Section 23 are required for permanent and temporary installations.

2. Emergency installations

The clearances required in Section 23 may be decreased for emergency installations if the following conditions are met.

NOTE: See Rule 14.

a. Open supply conductors of 0 to 750 V and supply cables meeting Rule 230C; and communication conductors and cables, guys, messengers, and neutral conductors meeting Rule 230E1 shall be suspended not less than 4.8 m (15.5 ft) above areas where trucks are expected, or 2.70 m (9 ft) above areas limited to pedestrians or restricted traffic only where vehicles are not expected during the emergency, unless Section 23 permits lesser clearances.

For the purpose of this rule, trucks are defined as any vehicle exceeding 2.5 m (8 ft) in height. Areas not subject to truck traffic are areas where truck traffic is neither normally encountered nor reasonably anticipated or is otherwise limited.

Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding 2.5 m (8 ft) in height are prohibited by regulation or permanent terrain configurations or are otherwise neither normally encountered nor reasonably anticipated or are otherwise limited.

b. Vertical clearances of open supply conductors above 750 V shall be increased above the applicable value of Rule 230A2a as appropriate for the voltage involved and the given local conditions.

c. Reductions in horizontal clearances permitted by this rule shall be in accordance with accepted good practice for the given local conditions during the term of the emergency.

d. Supply and communication cables may be laid directly on grade if they are guarded or otherwise located so that they do not unduly obstruct pedestrian or vehicular traffic and are appropriately marked. Supply cables operating above 600 V shall meet either Rule 230C or 350B. See Rules 311C and 014A2.

e. No clearance is specified for areas where access is limited to qualified personnel only.

3. Measurement of clearance and spacing

Unless otherwise stated, all clearances shall be measured from surface to surface and all spacings shall be measured center to center. For clearance measurements, energized metallic hardware used to secure or support supply line conductors and communication equipment used to secure or support communication line conductors shall be considered a part of the line conductors. Metallic bases of potheads, surge arresters, and similar devices shall be considered a part of the supporting structure.

4. Rounding of calculation results

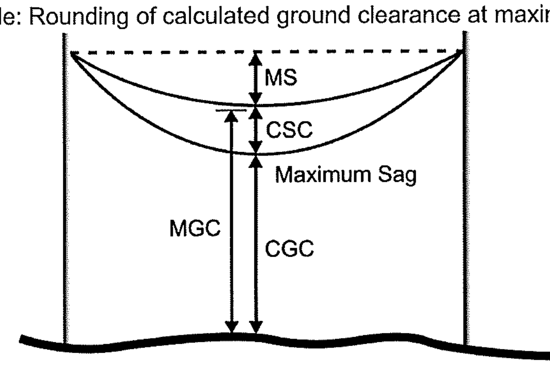
Unless otherwise specified in a table or rule within Section 23, clearance specifications that require a calculation to determine the required clearance shall have the resultant of the calculation rounded up to the same level of decimal places as the basic value shown in the rule or table, regardless of the numbers of significant digits of individual values required to be used in the calculation.

If a calculated clearance is allowed a reduction by footnotes or *EXCEPTIONS*, the resultant calculation shall be rounded up before the reduction is applied, and the resultant calculation after the reduction is applied shall also be rounded up.

EXCEPTION 1: Resultants of calculations expressed in millimeters shall be rounded up to the next multiple of 25 mm (1 in).

EXCEPTION 2: When determining a clearance at specified conditions based on field measurements, the resultant calculation shall be rounded down.

Example: Rounding of calculated ground clearance at maximum sag



MGC = Measured ground clearance = 5.69 m (18.67 ft)
MS = Measured sag @ 28 °C (82 °F) conductor temperature = 0.66 m (2.15 ft)
CSC = Calculated sag change from 28 °C (82 °F) to maximum sag due to thermal or ice loading = 0.77 m (2.52 ft)
CGC = Calculated ground clearance at maximum sag = 4.92 m (16.15 ft) = 4.9 m (16.1 ft) when rounded down to the next 0.1 m (0.1 ft)

Actual clearance aboveground was measured to be 5.69 m (18.67 ft) when the conductor was measured to be at 28 °C (82 °F). The sag at that conductor temperature was measured to be 0.66 m (2.15 ft). The measured sag, conductor temperature, and span length were used in sag and tension software to calculate the change in sag from the measured condition to the maximum sag produced by either ice loading or maximum conductor temperature. The change in sag from the measurement condition to the maximum sag condition was calculated to be 0.77 m (2.52 ft). Thus, the ground clearance when at maximum sag is calculated to be 5.69 m – 0.77 m = 4.92 m (18.67 ft – 2.52 ft = 16.15 ft).

Since the clearances of Table 232-1 are specified in 0.1 m (0.1 ft) increments, the calculated clearance 4.92 m (16.15 ft) must be rounded down to the next lower 0.1 m (0.1 ft) 4.9 m (16.1 ft) and compared to the required clearance to determine if the Code requirements are met. For example, if this conductor was an effectively grounded supply neutral conductor meeting Rule 230E1, crossing a field, it would meet the 4.7 m (15.5 ft) required for a neutral over a field when at final sag that is required by Table 232-1, row 4, other lands. However, if the conductor were a primary voltage supply conductor of 7200 V to ground, the clearance would not meet the 5.6 m (18.5 ft) required at maximum sag by the same table and row for that voltage.

B. Ice and wind loading for clearances

1. Four general degrees of loading due to weather conditions are recognized and are designated as clearance zones 1, 2, 3, and 4. Figure 230-1 shows the zones where these loadings apply.

NOTE: The localities are classified in the different zones according to the relative simultaneous prevalence of the wind velocity and thickness of ice that accumulates on wires. Zone 3 is for places where little, if any, ice accumulates on wires. Zone 4 applies to warm islands located from latitude 25 degrees south through 25 degrees north where mild temperatures exist at sea level, but icing may occur at altitudes above 2743 m (9000 ft) above sea level. See Appendix B.

2. Table 230-1 shows the radial thickness of ice to be used in calculating sags for clearance purposes. See applicable clearance rules in Section 23.

3. Ice and wind loads are specified in Rule 230B1.

   a. Where a cable is attached to a messenger, the specified loads shall be applied to both cable and messenger.

   b. In determining wind loads on a conductor or cable without ice covering, the assumed projected area shall be that of a smooth cylinder whose outside diameter is the same as that of the conductor or cable. The force coefficient (shape factor) for cylindrical surfaces is assumed to be 1.0.

      NOTE: Experience has shown that as the size of multiconductor cable decreases, the actual projected area decreases, but the roughness factor increases and offsets the reduction in projected area.

   c. An appropriate mathematical model shall be used to determine the wind and weight loads on ice-coated conductors and cables. In the absence of a model developed in accordance with Rule 230B5, the following mathematical model shall be used:

      (1) On a conductor, lashed cable, or multiple-conductor cable, the coating of ice shall be considered to be a hollow cylinder touching the outer strands of the conductor or the outer circumference of the lashed cable or multiple-conductor cable.

      (2) On bundled conductors, the coating of ice shall be considered as individual hollow cylinders around each subconductor.

   d. It is recognized that the effects of conductor stranding or of non-circular cross section may result in wind and ice loadings more or less than those calculated according to assumptions stated in Rules 230B3b and 230B3c. No reduction in these loadings is permitted unless testing or a qualified engineering study justifies a reduction.

4. Table 230-2 shows the radial thickness of ice, wind pressures, temperatures, and additive constants to be used in calculating inelastic deformation.

   The load components shall be determined as follows:

   a. Vertical load component

      The vertical load on a wire, conductor, or messenger shall be its own weight plus the weight of conductors, spacers, or equipment that it supports, ice covered where required by Rule 230B1 and Table 230-2.

   b. Horizontal load component

      The horizontal load shall be the horizontal wind pressure determined under Rule 230B1 and Table 230-2, applied at right angles to the direction of the line using the projected area of the conductor or messenger and conductors, spacers, or equipment that it supports, ice covered where required by Rule 230B1 and Table 230-2.

      NOTE: The projected area of the conductor or messenger is equal to the diameter of the conductor or messenger, plus ice if appropriate, multiplied by the span length. See Rule 251A2 for force coefficient values of different surface shapes.

   c. Total load

      The total load on each wire, conductor, or messenger shall be the resultant of components in a) and b) above, calculated at the applicable temperature in Table 230-2, plus the corresponding additive constant in Table 230-2.

5. Final sag calculations shall include the effects of inelastic deformation due to both (a) initial and subsequent combined ice and wind loading, and (b) long-term material deformation (creep). See applicable **sag** definitions. Ice is assumed to weigh 913 kg/m^3 (57 lb/ft^3).

C. Supply cables

For clearance purposes, supply cables, including splices and taps, conforming to any of the following requirements are permitted lesser clearances than open conductors of the same voltage. Cables should be capable of withstanding tests applied in accordance with an applicable standard.

1. Cables that are supported on or cabled together with an effectively grounded bare messenger or neutral, or with multiple concentric neutral conductors, where any associated neutral conductor(s) meet(s) the requirements of Rule 230E1 and where the cables also meet one of the following:

   a. Cables of any voltage having an effectively grounded continuous metal sheath or shield

   b. Cables designed to operate on a multi-grounded system at 22 kV or less and having semiconducting insulation shielding in combination with suitable metallic drainage

2. Cables of any voltage, not included in Rule 230C1, covered with a continuous auxiliary semi-conducting shield in combination with suitable metallic drainage and supported on and cabled together with an effectively grounded bare messenger.

3. Insulated, nonshielded cable operated at not over 5 kV phase to phase, or 2.9 kV phase to ground, supported on and cabled together with an effectively grounded bare messenger or neutral.

D. Covered conductors

Covered conductors shall be considered bare conductors for all clearance requirements except that clearance between conductors of the same or different circuits, including grounded conductors, may be reduced below the requirements for open conductors when the conductors are owned, operated, or maintained by the same party and when the conductor covering provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact between conductors or between conductors and the grounded conductor. Intermediate spacers may be used to maintain conductor clearance and to provide support.

E. Neutral conductors

1. Neutral conductors that are effectively grounded throughout their length and associated with circuits of 0 to 22 kV to ground may have the same clearances as guys and messengers.

2. All other neutral conductors of supply circuits shall have the same clearances as the phase conductors of the circuit with which they are associated.

F. Fiber-optic cable

1. Fiber-optic—supply cable

   a. Cable defined as "fiber-optic—supply" supported on a messenger that is effectively grounded throughout its length shall have the same clearance from communications facilities as required for a neutral conductor meeting Rule 230E1.

   b. Cable defined as "fiber-optic—supply" that is entirely dielectric, or supported on a messenger that is entirely dielectric, shall have the same clearance from communications facilities as required for a neutral conductor meeting Rule 230E1.

      NOTE: A fiber-optic cable that is entirely dielectric is one such as ADSS (All Dielectric Self-Supporting) cable.

   c. Fiber-optic—supply cables supported on or within messengers not meeting Rule 230F1a or 230F1b shall have the same clearances from communications facilities required for such messengers.

   d. Fiber-optic—supply cables supported on or within a conductor(s), or containing a conductor(s) or cable sheath(s) within the fiber-optic cable assembly shall have the same clearances from communications facilities required for such conductors. Such clearance shall be not less than that required under Rule 230F1a, 230F1b, or 230F1c, as applicable.

   e. Fiber-optic—supply cables meeting Rule 224A3 are considered to be communication cables when located in the communication space.

2. Fiber-optic—communication cable

Cable defined as "fiber-optic—communication" shall have the same clearance from supply facilities as required for a communication messenger.

G. Alternating- and direct-current circuits

The rules of this section are applicable to both ac and dc circuits. For dc circuits, the clearance requirements shall be the same as those for ac circuits having the same crest voltage to ground.

NOTE: Although the corresponding crest voltage for a common sinusoidal ac circuit may be calculated by multiplying its rms value by 1.414 (square root of 2), this may not be appropriate for other type ac circuits. An example of the latter is represented by non-sinusoidal power supplies such as used in some coaxial cable type communication systems.

H. Constant-current circuits

The clearances for constant-current circuits (such as series lighting circuits) shall be determined on the basis of their normal full-load voltage.

I. Maintenance of clearances and spacings

The clearances and spacing required shall be maintained at the values and under the conditions specified in Section 23 of the applicable edition. The clearances of Section 23 are not intended to be maintained during the course of or as a result of abnormal events such as, but not limited to, actions of others or weather events in excess of those described under Section 23. Utilities are responsible for correcting known non-compliant conditions in accordance with Rule 214A4 or Rule 214A5 as applicable.

NOTE: See Rule 13 to determine the applicable edition.

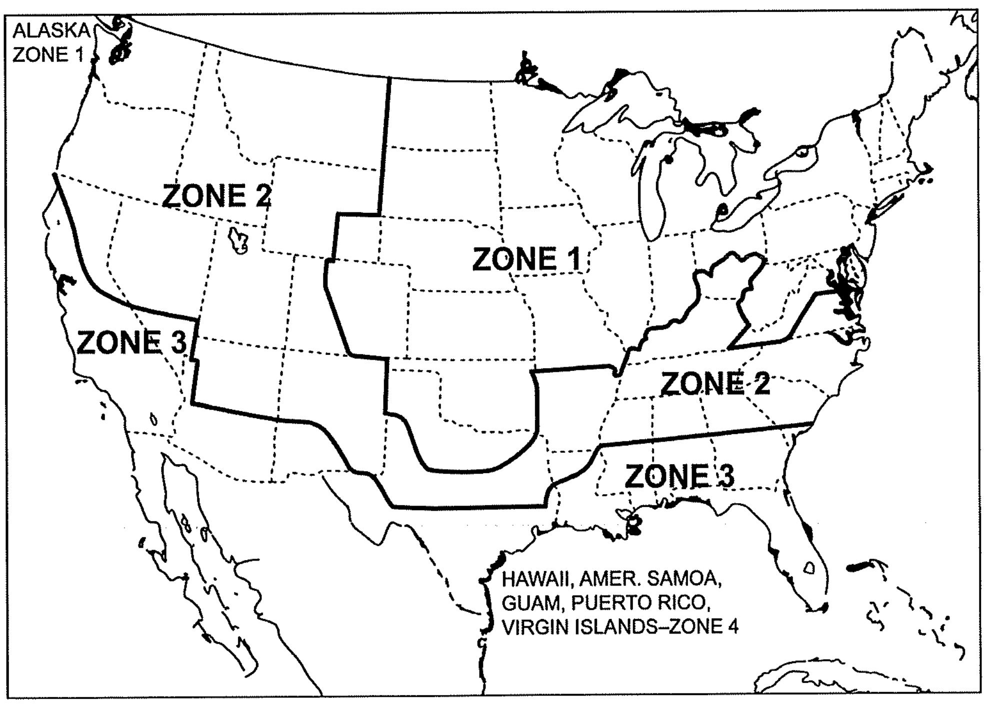


Figure 230-1—Clearance zone map of the United States

Clearance Zone 4 includes American Samoa, Guam, Hawaii, Puerto Rico, Virgin Islands, and other warm islands located from 0 to 25 degrees latitude, north or south.

Table 230-1—Ice thickness for purposes of calculating clearances

	Clearance zone (for use with Rules 232, 233, 234, and 235)				
				Zone 4: Warm islands ①	
	Zone 1 see Figure 230-1	Zone 2 see Figure 230-1	Zone 3 see Figure 230-1	Altitudes sea level to 2743 m (9000 ft)	Altitudes above 2743 m (9000 ft)
Radial thickness of ice					
(mm)	12.5	6.5	0	0	6.5
(in)	0.50	0.25	0	0	0.25

① Warm islands are those located from latitude 25 degrees south through 25 degrees north and include American Samoa (14°S), Guam (13°N), Hawaii (22°N), Puerto Rico (18°N), and Virgin Islands (18°N).

Table 230-2—Ice, wind pressures, temperatures, and additive constants for purposes of calculating final inelastic deformation

	Clearance zone (for use with Rules 232, 233, 234, and 235)				
				Zone 4: Warm islands ①	
	Zone 1 Heavy ice: see Figure 230-1	Zone 2 Moderate ice: see Figure 230-1	Zone 3 Little or no ice: see Figure 230-1	Altitudes sea level to 2743 m (9000 ft)	Altitudes above 2743 m (9000 ft)
Radial thickness of ice					
(mm)	12.5	6.5	0	0	6.5
(in)	0.50	0.25	0	0	0.25
Horizontal wind pressure					
(Pa)	190	190	430	430	190
(lb/ft^2)	4	4	9	9	4
Temperature					
(°C)	–20	–10	–1	+10	–10
(°F)	0	+15	+30	+50	+15
Constant to be added to the resultant ②					
(N/m)	4.40	2.90	0.73	0.73	2.90
(lb/ft)	0.30	0.20	0.05	0.05	0.20

① Warm islands are those located from latitude 25 degrees south through 25 degrees north and include American Samoa (14°S), Guam (13°N), Hawaii (22°N), Puerto Rico (18°N), and Virgin Islands (18°N).
② For cable arrangements supported by a messenger using spacers or rings and where each conductor or cable is separately loaded with ice and wind as described in Rule 230B3c(2) [as opposed to being analyzed with the ice and wind applied to a hollow cylinder touching the outer strands of the conductors as described in Rule 230B3c(1)], the constant specified here shall be added to the resultant load of each component conductor and the messenger.

231. Clearances of supporting structures from other objects

Supporting structures, support arms, anchor guys, and equipment attached thereto, and braces shall have the following clearances from other objects. The clearance shall be measured between the nearest parts of the objects concerned.

A. From fire hydrants

Not less than 1.2 m (4 ft).

EXCEPTION 1: Where conditions do not permit, a clearance of not less than 900 mm (3 ft) is allowed.

EXCEPTION 2: Clearances in Rule 231A may be reduced by agreement with the local fire authority and the pole owner.

B. From streets, roads, and highways

1. Where there are curbs: supporting structures, support arms, anchor guys, or equipment attached thereto, up to 4.6 m (15 ft) above the road surface shall be located a sufficient distance behind the curb to avoid contact by ordinary vehicles using and located on the traveled way.
2. Where there are no curbs, supporting structures should be located a sufficient distance from the roadway to avoid contact by ordinary vehicles using and located on the traveled way.
3. Location of overhead utility installations on roads, streets, or highways with narrow rights-of-way or closely abutting improvements are special cases that must be resolved in a manner consistent with the prevailing limitations and conditions.
4. Where a governmental authority exercising jurisdiction over structure location has issued a permit for, or otherwise approved, specific locations for supporting structures, that permit or approval shall govern.

C. From railroad tracks

Where railroad tracks are parallel to or crossed by overhead lines, all portions of the supporting structures, support arms, anchor guys, and equipment attached thereto less than 6.7 m (22 ft) above the nearest track rail shall have horizontal clearances not less than the values required by Rule 231C1 or 231C2 for the situation concerned.

NOTE: See Rule 234I.

1. Not less than 3.6 m (12 ft) from the nearest track rail.

   EXCEPTION 1: A clearance of not less than 2.13 m (7 ft) may be allowed where the supporting structure is not the controlling obstruction, provided sufficient space for a driveway is left where cars are loaded or unloaded.

   EXCEPTION 2: Supports for overhead trolley-contact conductors may be located as near their own track rail as conditions require. If very close, however, permanent screens on cars will be necessary to protect passengers.

   EXCEPTION 3: Where necessary to provide safe operating conditions that require an uninterrupted view of signals, signs, etc., along tracks, the parties concerned shall cooperate in locating structures to provide the necessary clearance.

   EXCEPTION 4: At industrial sidings, a clearance of not less than 2.13 m (7 ft) shall be permitted, provided sufficient space is left where cars can be loaded or unloaded.
2. The clearances of Rule 231C1 may be reduced by agreement with the railroad(s).

232. Vertical clearances of wires, conductors, cables, and equipment aboveground, roadway, rail, or water surfaces

A. Application

The vertical clearances specified in Rule 232B1 apply under the following conductor temperature and loading conditions, whichever produces the largest final sag:

1. 50 °C (120 °F), no wind displacement

2. The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C (120 °F), with no wind displacement

3. 0 °C (32 °F), no wind displacement, with radial thickness of ice, if any, specified in Table 230-1 for the zone concerned

   EXCEPTION: The conductor temperature and loading condition for trolley and electrified railroad contact conductors shall be 15 °C (60 °F), no wind displacement, final sag, or initial sag in cases where these facilities are maintained approximately at initial sags.

   NOTE: The phase and neutral conductors of a supply line are normally considered separately when determining the sag of each due to temperature rise.

B. Clearance of wires, conductors, cables, equipment, and support arms mounted on supporting structures

NOTE: Neither horizontal nor diagonal clearances are specified in this rule. As a result, Rule 012C requires good practice for the given local conditions.

1. Clearance to wires, conductors, and cables

   The vertical clearance of wires, conductors, and cables aboveground in generally accessible places, roadway, rail, or water surfaces, shall be not less than that shown in Table 230-1.

2. Clearance to unguarded rigid live parts of equipment

   The vertical clearance above ground, roadway, or water surfaces for unguarded rigid live parts such as potheads, transformer bushings, surge arresters, and short lengths of supply conductors connected thereto, which are not subject to variation in sag, shall be not less than that shown in Table 232-2. For clearances of drip loops of service drops, see Table 230-1.

3. Clearance to support arms, switch handles, and equipment cases

   The vertical clearance of switch handles, equipment cases, support arms, platforms, and braces that extend beyond the surface of the structure shall be not less than that shown in Table 232-2. These clearances do not apply to internal structural braces for latticed towers, X-braces between poles, and pole-type push braces.

4. Street and area lighting

   a. The vertical clearance of street and area lighting luminaires shall be not less than that shown in Table 232-2. For this purpose, grounded luminaire cases and brackets shall be considered as effectively grounded equipment cases; ungrounded luminaire cases and brackets shall be considered as a rigid live part of the voltage contained.

      EXCEPTION: This rule does not apply to post-top mounted luminaires with effectively grounded or entirely dielectric cases.

   b. Insulators, as specified in Rule 279A, should be inserted at least 2.45 m (8 ft) from the ground in metallic suspension ropes or chains supporting lighting units of series circuits.

C. Additional clearances for wires, conductors, cables, and unguarded rigid live parts of equipment

Greater clearances than specified by Rule 232B shall be provided where required by Rule 232C1.

1. Voltages exceeding 22 kV

   a. For voltages between 22 and 470 kV, the clearance specified in Rule 232B1 (Table 232-1) or Rule 232B2 (Table 232-2) shall be increased at the rate of 10 mm (0.4 in) per kilovolt in excess of 22 kV. For voltages exceeding 470 kV, the clearance shall be determined by the method given in Rule 232D. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

      EXCEPTION: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required above are permitted for systems with known maximum switching-surge factors (see Rule 232D).

   b. For voltages exceeding 50 kV, the additional clearance specified in Rule 232C1a shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level.

c. For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means as required to limit the steady-state current due to electrostatic effects to 5 mA rms if the largest anticipated truck, vehicle, or equipment under the line were short-circuited to ground. The size of the anticipated truck, vehicle, or equipment used to determine these clearances may be less than but need not be greater than that limited by federal, state, or local regulations governing the area under the line. For this determination, the conductors shall be at a final sag at 50 °C (120 °F).

D. Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 232B and 232C may be reduced for circuits with known switching-surge factors, but shall be not less than the alternate clearance, which is computed by adding the reference height from Rule 232D2 to the electrical component of clearance from Rule 232D3.

1. Sag conditions of line conductors

The vertical clearance shall be maintained under the conductor temperature and loading condition given in Rule 232A.

2. Reference heights

The reference height shall be selected from Table 232-3.

3. Electrical component of clearance

a. The electrical component (D) shall be computed using the following equations. Selected values of D are listed in Table 232-4.

$$D = 1.00\left[\frac{V\cdot(PU)\cdot a}{500K}\right]^{1.667} bc \quad \text{(m)}$$

$$D = 3.28\left[\frac{V\cdot(PU)\cdot a}{500K}\right]^{1.667} bc \quad \text{(ft)}$$

where

V = maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

c = 1.2, the margin of safety

K = 1.15, the configuration factor for conductor-to-plane gap

b. The value of D shall be increased 3% for each 300 m (1000 ft) in excess of 450 m (1500 ft) above mean sea level.

c. For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means as required to limit the steady state current due to electrostatic effects to 5 mA, rms, if the largest anticipated truck, vehicle, or equipment under the line were short-circuited to ground. The size of the anticipated truck, vehicle, or equipment used to determine these clearances may be less than but need not be greater than that limited by federal, state, or local regulations governing the area under the line. For this determination, the conductors shall be at a final sag at 50 °C (120 °F).

4. Limit

The alternate clearance shall be not less than the clearance given in Table 232-1 or Table 232-2 computed for 98 kV ac to ground in accordance with Rule 232C.

m

Table 232-1— Vertical clearance of wires, conductors, and cables above ground, roadway, rail, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B1, 232C1a, and 232D4.)

Nature of surface underneath wires, conductors, or cables	Insulated communication conductors and cable; messengers; overhead shield/surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V [6] [11] [15]; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V [3]; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 300 V to 750 V [6][14][15] (m)	Open supply conductors, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 750 V to 22 kV [6][14][15] (m)	Trolley and electrified railroad contact conductors and associated span or messenger wires [1]	
					0 to 750 V to ground (m)	Over 750 V to 22 kV to ground (m)
Where wires, conductors, or cables cross over or overhang						
1. Track rails of railroads (except electrified railroads using overhead trolley conductors) [2] [16] [22]	7.2	7.3	7.5	8.1	6.7 [4]	6.7 [4]
2. Roads, streets, and other areas subject to truck traffic [23]	4.7	4.9	5.0	5.6	5.5 [5]	6.1 [5]
3. Driveways, parking lots, and alleys [23]	4.7 [7] [13]	4.9 [7] [13]	5.0 [7]	5.6	5.5 [5]	6.1 [5]
4. Other areas traversed by vehicles, such as cultivated, grazing, forest, and orchard lands, industrial sites, commercial sites, etc. [24]	4.7	4.9	5.0	5.6	—	—
5. Spaces and ways subject to pedestrians or restricted traffic only [9]	2.9	3.6 [8]	3.8 [8]	4.4	4.9	5.5

m

Table 232-1— *(continued)*
Vertical clearance of wires, conductors, and cables above ground, roadway, rail, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B1, 232C1a, and 232D4.)

Nature of surface underneath wires, conductors, or cables	Insulated communication conductors and cable; messengers; overhead shield/surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ⑥ ⑪ ⑮; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ③; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 300 V to 750 V ⑥⑭⑮ (m)	Open supply conductors, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 750 V to 22 kV ⑥⑭⑮ (m)	Trolley and electrified railroad contact conductors and associated span or messenger wires ①	
					0 to 750 V to ground (m)	Over 750 V to 22 kV to ground (m)
6. Water areas not suitable for sailboating or where sailboating is prohibited ㉑	4.0	4.4	4.6	5.2	—	—
7. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of ⑰ ⑱ ⑲ ⑳ ㉑						
a. Less than 0.08 km^2	5.3	5.5	5.6	6.2	—	—
b. Over 0.08 to 0.8 km^2	7.8	7.9	8.1	8.7	—	—
c. Over 0.8 to 8 km^2	9.6	9.8	9.9	10.5	—	—
d. Over 8 km^2	11.4	11.6	11.7	12.3	—	—
8. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sail boats	Clearance aboveground shall be 1.5 m greater than in 7 above, for the type of water areas served by the launching sites					
Where wires, conductors, or cables run along and within the limits of highways or other road rights-of-way but do not overhang the roadway						
9. Roads, streets, or alleys	4.7 ㉔	4.9	5.0	5.6	5.5 ⑤	6.1 ⑤
10. Roads where it is unlikely that vehicles will be crossing under the line	4.1 ⑩ ⑫	4.3 ⑩	4.4 ⑩	5.0	5.5 ⑤	6.1 ⑤

NOTE: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2a of Appendix A.

①Where subways, tunnels, or bridges require it, less clearance above ground or rails than required by Table 232-1 may be used locally. The trolley and electrified railroad contact conductor should be graded gradually from the regular construction down to the reduced elevation.

②For wires, conductors, or cables crossing over mine, logging, and similar railways that handle only cars lower than standard freight cars, the clearance may be reduced by an amount equal to the difference in height between the highest loaded car handled and 6.1 m, but the clearance shall not be reduced below that required for street crossings.

③Does not include neutral conductors meeting Rule 230E1.

④In communities where 6.4 m has been established, this clearance may be continued if carefully maintained. The elevation of the contact conductor should be the same in the crossing and next adjacent spans. (See Rule 225D2 for conditions that must be met where uniform height above rail is impractical.)

⑤In communities where 4.9 m has been established for trolley and electrified railroad contact conductors 0 to 750 V to ground, or 5.5 m for trolley and electrified railroad contact conductors exceeding 750 V, or where local conditions make it impractical to obtain in the clearance given in the table, these reduced clearances may be used if carefully maintained.

⑥These clearance values also apply to guy insulators.

⑦Where vehicles exceeding 2.45 m in height are not normally encountered nor reasonably anticipated, service drop(s) clearances over residential driveways only may be reduced to the following:

		(m)
(a)	Insulated supply service drops limited to 300 V to ground	3.8
(b)	Insulated drip loops of supply service drops limited to 300 V to ground	3.2
(c)	Supply service drops limited to 150 V to ground and meeting Rule 230C1 or 230C3	3.6
(d)	Drip loops only of service drops limited to 150 V to ground and meeting Rule 230C1 or 230C3	3.0
(e)	Insulated communication service drops	3.5

⑧These clearance values for service drops to residential buildings only may be reduced to the following:

		(m)
(a)	Insulated supply service drops limited to 300 V to ground	3.2
(b)	Insulated drip loops of supply service drops limited to 300 V to ground	3.2
(c)	Supply service drops limited to 150 V to ground and meeting Rule 230C1 or 230C3	3.0
(d)	Drip loops only of supply service drops limited to 150 V to ground and meeting Rule 230C1 or 230C3	3.0

⑨Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horses or other large animals, vehicles, or other mobile units exceeding a total height of 2.45 m, are prohibited by regulation or permanent terrain configurations, or are otherwise not normally encountered nor reasonably anticipated.

⑩Where a supply or communication line along a road is located relative to fences, ditches, embankments, or other terrain features so that the ground under the line would not be expected to be traveled except by pedestrians, the clearances may be reduced to the following values:

		(m)
(a)	Insulated communication conductor and communication cables	2.9
(b)	Conductors of other communication circuits	2.9
(c)	Supply cables of any voltage meeting Rule 230C1 and neutral conductors meeting Rule 230E1	2.9
(d)	Insulated supply conductors limited to 300 V to ground	3.8
(e)	Insulated supply cables limited to 150 V to ground meeting Rule 230C2 or 230C3	3.1
(f)	Effectively grounded guys, insulated guys meeting Rules 279A1 and 215C2 exposed to 0 to 300 V	2.9

⑪No clearance from ground is required for anchor guys not crossing tracks, rails, streets, driveways, roads, or pathways.

⑫This clearance may be reduced to 4.0 m for communication conductors and guys.

⑬Where this construction crosses over or runs along (a) alleys, non-residential driveways, or parking lots not subject to truck traffic, or (b) residential driveways, this clearance may be reduced to 4.6 m.

⑭The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

⑮The portion of anchor guys below the lowest insulator meeting Rules 279A1 and 215C2a may have the same clearance as effectively grounded guys.

⑯Adjacent to tunnels and overhead bridges that restrict the height of loaded rail cars to less than 6.1 m, these clearances may be reduced by the difference between the highest loaded rail car handled and 6.1 m, if mutually agreed to by the parties at interest.

⑰For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level.

⑱For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.

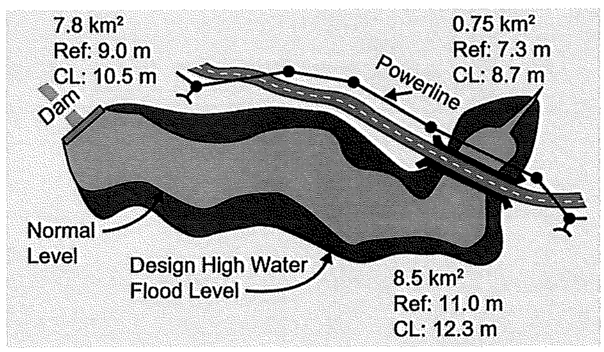
⑲The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1.6 km long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

⑳Where a bridge or other overwater obstruction restricts vessel height to less than the applicable reference height given in Table 232-3, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height for the area of the body of water over which the line crosses, except that the reduced clearance shall be not less than that required for the surface area on the line-crossing side of the obstruction.

EXAMPLE: If an 8.5 km^2 lake (over 8.0 km^2; reference height 11.0 m) consists of 7.8 km^2 (0.8 to 8.0 km^2; reference height 9.0 m) on one side of a bridge and 0.75 km^2 (0.08 to 8.0 km^2; reference height 7.3 m) on the other side of the bridge, the required line clearance must be not less than that required for an over 8.0 km^2 lake as required by Table 232-1 unless the bridge height above design high water is less than the reference dimension of 11.0 m.

If the line is placed on the 0.75 km^2 side and the bridge height above design high water is less than 11.0 m, but more than 7.3 m, the required line clearance is reduced from that required by a lake of over 8.0 km^2 by the difference between the bridge clearance and 11.0 m. If the bridge height above design high water is less than 7.3 m, the required clearance remains at that required for a 0.8 to 8.0 km^2 lake. See following figure.

Similarly, if the line is placed on the 7.8 km^2 side and the bridge height above design high water is less than 11.0 m, but more than 9.0 m, the required line clearance is reduced from that required by a lake of over 8.0 km^2 by the difference between the bridge clearance and 11.0 m. If the bridge height above design high water is less than 9.0 m, the required clearance remains at that required for a 0.8 to 8.0 km^2 lake.



Power line on small lake side of bridge

㉑Where the U.S. Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearances of that permit shall govern.

㉒See Rule 234I for the required horizontal and diagonal clearances to rail cars.

㉓For the purpose of this rule, trucks are defined as any vehicle exceeding 2.45 m in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

㉔Communication cables and conductors may have a clearance of not less than 4.6 m where poles are back of curbs or other deterrents to vehicular traffic.

㉕This footnote not used in this edition.

㉖When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 4.3 m.

ft

Table 232-1— Vertical clearance of wires, conductors, and cables above ground, roadway, rail, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B1, 232C1a, and 232D4.)

Nature of surface underneath wires, conductors, or cables	Insulated communication conductors and cable; messengers; overhead shield/surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ⑥⑪⑮; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (ft)	Noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ③; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 300 V to 750 V ⑥⑭⑮ (ft)	Open supply conductors, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 750 V to 22 kV ⑥⑭⑮ (ft)	Trolley and electrified railroad contact conductors and associated span or messenger wires ①	
					0 to 750 V to ground (ft)	Over 750 V to 22 kV to ground (ft)
Where wires, conductors, or cables cross over or overhang						
1. Track rails of railroads (except electrified railroads using overhead trolley conductors) ② ⑯ ㉒	23.5	24.0	24.5	26.5	22.0 ④	22.0 ④
2. Roads, streets, and other areas subject to truck traffic ㉓	15.5	16.0	16.5	18.5	18.0 ⑤	20.0 ⑤
3. Driveways, parking lots, and alleys ㉓	15.5 ⑦ ⑬	16.0 ⑦ ⑬	16.5 ⑦	18.5	18.0 ⑤	20.0 ⑤
4. Other areas traversed by vehicles, such as cultivated, grazing, forest, and orchard lands, industrial sites, commercial sites, etc. ㉖	15.5	16.0	16.5	18.5	—	—
5. Spaces and ways subject to pedestrians or restricted traffic only ⑨	9.5	12.0 ⑧	12.5 ⑧	14.5	16.0	18.0
6. Water areas not suitable for sailboating or where sailboating is prohibited ㉑	14.0	14.5	15.0	17.0	—	—

ft

Table 232-1— *(continued)*
Vertical clearance of wires, conductors, and cables above ground, roadway, rail, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B1, 232C1a, and 232D4.)

Nature of surface underneath wires, conductors, or cables	Insulated communication conductors and cable; messengers; overhead shield/surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V [6] [11] [15]; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (ft)	Noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V [3]; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 300 V to 750 V [6][14][15] (ft)	Open supply conductors, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 750 V to 22 kV [6][14][15] (ft)	Trolley and electrified railroad contact conductors and associated span or messenger wires [1]	
					0 to 750 V to ground (ft)	Over 750 V to 22 kV to ground (ft)
7. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of [17] [18] [19] [20] [21]						
a. Less than 20 acres	17.5	18.0	18.5	20.5	—	—
b. Over 20 to 200 acres	25.5	26.0	26.5	28.5	—	—
c. Over 200 to 2000 acres	31.5	32.0	32.5	34.5	—	—
d. Over 2000 acres	37.5	38.0	38.5	40.5	—	—
8. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sail boats	Clearance aboveground shall be 5 ft greater than in 7 above, for the type of water areas served by the launching site					
Where wires, conductors, or cables run along and within the limits of highways or other road rights-of-way but do not overhang the roadway						
9. Roads, streets, or alleys	15.5 [24]	16.0	16.5	18.5	18.0 [5]	20.0 [5]
10. Roads where it is unlikely that vehicles will be crossing under the line	13.5 [10] [12]	14.0 [10]	14.5 [10]	16.5	18.0 [5]	20.0 [5]

NOTE: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2a of Appendix A.

①Where subways, tunnels, or bridges require it, less clearance above ground or rails than required by Table 232-1 may be used locally. The trolley and electrified railroad contact conductor should be graded gradually from the regular construction down to the reduced elevation.

②For wires, conductors, or cables crossing over mine, logging, and similar railways that handle only cars lower than standard freight cars, the clearance may be reduced by an amount equal to the difference in height between the highest loaded car handled and 20 ft, but the clearance shall not be reduced below that required for street crossings.

③Does not include neutral conductors meeting Rule 230E1.

④In communities where 21 ft has been established, this clearance may be continued if carefully maintained. The elevation of the contact conductor should be the same in the crossing and next adjacent spans. (See Rule 225D2 for conditions that must be met where uniform height above rail is impractical.)

⑤In communities where 16 ft has been established for trolley and electrified railroad contact conductors 0 to 750 V to ground, or 18 ft for trolley and electrified railroad contact conductors exceeding 750 V, or where local conditions make it impractical to obtain the clearance given in the table, these reduced clearances may be used if carefully maintained.

⑥These clearance values also apply to guy insulators.

⑦Where vehicles exceeding 8 ft in height are not normally encountered nor reasonably anticipated, service drop(s) clearances over residential driveways only may be reduced to the following:

		(ft)
(a)	Insulated supply service drops limited to 300 V to ground	12.5
(b)	Insulated drip loops of supply service drops limited to 300 V to ground	10.5
(c)	Supply service drops limited to 150 V to ground and meeting Rule 230C1 or 230C3	12.0
(d)	Drip loops only of service drops limited to 150 V to ground and meeting Rule 230C1 or 230C3	10.0
(e)	Insulated communication service drops	11.5

⑧These clearances values for service drops to residential buildings only may be reduced to the following:

		(ft)
(a)	Insulated supply service drops limited to 300 V to ground	10.5
(b)	Insulated drip loops of supply service drops limited to 300 V to ground	10.5
(c)	Supply service drops limited to 150 V to ground and meeting Rule 230C3	10.0
(d)	Drip loops only of supply service drops limited to 150 V to ground and meeting Rule 230C3	10.0

⑨Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horses or other large animals, vehicles, or other mobile units exceeding a total height of 8 ft are prohibited by regulation or permanent terrain configurations, or are otherwise not normally encountered nor reasonably anticipated.

⑩Where a supply or communication line along a road is located relative to fences, ditches, embankments, or other terrain features so that the ground under the line would not be expected to be traveled except by pedestrians, the clearances may be reduced to the following values:

		(ft)
(a)	Insulated communication conductor and communication cables.	9.5
(b)	Conductors of other communication circuits	9.5
(c)	Supply cables of any voltage meeting Rule 230C1 and neutral conductors meeting Rule 230E1	9.5
(d)	Insulated supply conductors limited to 300 V to ground	12.5
(e)	Insulated supply cables limited to 150 V to ground meeting Rule 230C2 or 230C3	10.0
(f)	Effectively grounded guys, insulated guys meeting Rules 279A1 and 215C2 exposed to 0 to 300 V	9.5

⑪No clearance from ground is required for anchor guys not crossing tracks, rails, streets, driveways, roads, or pathways.

⑫This clearance may be reduced to 13 ft for communication conductors and guys.

⑬Where this construction crosses over or runs along (a) alleys, non-residential driveways, or parking lots not subject to truck traffic, or (b) residential driveways, this clearance may be reduced to 15 ft.

⑭The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

⑮The portion of anchor guys below the lowest insulator meeting Rules 279A1 and 215C2a may have the same clearance as effectively grounded guys.

⑯Adjacent to tunnels and overhead bridges that restrict the height of loaded rail cars to less than 20 ft, these clearances may be reduced by the difference between the highest loaded rail car handled and 20 ft, if mutually agreed to by the parties at interest.

⑰For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level.

⑱For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.

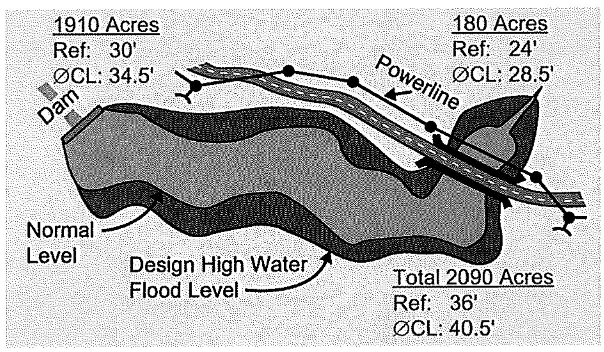
⑲The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1 mi long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

⑳Where a bridge or other overwater obstruction restricts vessel height to less than the applicable reference height given in Table 232-3, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height for the area of the body of water over which the line crosses, except that the reduced clearance shall be not less than that required for the surface area on the line-crossing side of the obstruction.

EXAMPLE: If a 2090 acre lake (over 2000 acres; reference height 36 ft) consists of 1910 acres (200 to 2000 acres; reference height 30 ft) on one side of a bridge and 180 acres (20 to 200 acres; reference height 24 ft) on the other side of the bridge, the required line clearance must be not less than that required for an over 2000 acre lake as required by Table 232-1 unless the bridge height above design high water is less than the reference dimension of 36 ft.

If the line is placed on the 180 acre side and the bridge height above design high water is less than 36 ft, but more than 24 ft, the required line clearance is reduced from that required by a lake of over 2000 acres by the difference between the bridge clearance and 36 ft. If the bridge height above design high water is less than 24 ft, the required clearance remains at that required for a 20 to 200 acre lake. See following figure.

Similarly, if the line is placed on the 1910 acre side and the bridge height above design high water is less than 36 ft, but more than 30 ft, the required line clearance is reduced from that required by a lake of over 2000 acres by the difference between the bridge clearance and 36 ft. If the bridge height above design high water is less than 30 ft, the required clearance remains at that required for a 200 to 2000 acre lake.



Power line on small lake side of bridge

㉑Where the U.S. Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearances of that permit shall govern.

㉒See Rule 234I for the required horizontal and diagonal clearances to rail cars.

㉓For the purpose of this rule, trucks are defined as any vehicle exceeding 8 ft in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

㉔Communication cables and conductors may have a clearance of not less than 15 ft where poles are back of curbs or other deterrents to vehicular traffic.

㉕This footnote not used in this edition.

㉖When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 14 ft.

m

Table 232-2—
Vertical clearance of equipment cases, support arms, platforms, braces and unguarded rigid live parts above ground, roadway, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B2, 232B3, 232C1a, and 232D4.)

Nature of surface below	Nonmetallic or effectively grounded support arms, switch handles, platforms, braces, and equipment cases (m)	Unguarded rigid live parts of 0 to 750 V and ungrounded cases that contain equipment connected to circuits of not more than 750 V (m)	Unguarded rigid live parts of over 750 V to 22 kV and ungrounded cases that contain equipment connected to circuits of over 750 V to 22 kV (m)
1. Where rigid parts overhang			
a. Roads, streets, and other areas subject to truck traffic [4]	4.6	4.9	5.5
b. Driveways, parking lots, and alleys	4.6	4.9 [6]	5.5
c. Other areas traversed by vehicles such as cultivated, grazing, forest, and orchard lands, industrial areas, commercial areas, etc. [3]	4.6 [7]	4.9	5.5
d. Spaces and ways subject to pedestrians or restricted traffic only [5]	2.8 [7]	3.6 [1]	4.3
2. Where rigid parts are along and within the limits of highways or other road rights-of-way but do not overhang the roadway			
a. Roads, streets, and alleys	4.6 [7]	4.9	5.5
b. Roads where it is unlikely that vehicles will be crossing under the line	4.0 [7]	4.3 [2]	4.9
3. Water areas not suitable for sailboating or where sailboating is prohibited [8]	4.1	4.4	5.0
4. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of [8] [9] [10] [11] [12]			
a. Less than 20 acres	5.2	5.5	6.1
b. Over 20 to 200 acres	7.6	7.9	8.5
c. Over 200 to 2000 acres	9.4	9.8	10.4
d. Over 2000 acres	11.3	11.6	12.2

m

Table 232-2— *(continued)*
Vertical clearance of equipment cases, support arms, platforms, braces and unguarded rigid live parts above ground, roadway, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B2, 232B3, 232C1a, and 232D4.)

Nature of surface below	Nonmetallic or effectively grounded support arms, switch handles, platforms, braces, and equipment cases (m)	Unguarded rigid live parts of 0 to 750 V and ungrounded cases that contain equipment connected to circuits of not more than 750 V (m)	Unguarded rigid live parts of over 750 V to 22 kV and ungrounded cases that contain equipment connected to circuits of over 750 V to 22 kV (m)
5. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sail boats	Clearance aboveground shall be 1.5 m greater than in 4 above, for the type of water areas served by the launching site		

NOTE: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2a of Appendix A.

①For insulated live parts limited to 150 V to ground, this value may be reduced to 3.0 m.

②Where a supply line along a road is limited to 300 V to ground and is located relative to fences, ditches, embankments, etc., so that the ground under the line would not be expected to be traveled except by pedestrians, this clearance may be reduced to 3.6 m.

③When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 4.3 m.

④For the purpose of this rule, trucks are defined as any vehicle exceeding 2.45 m in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

⑤Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding 2.45 m in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

⑥This clearance may be reduced to the following values for driveways, parking lots, and alleys not subject to truck traffic:

	(m)
(a) Insulated live parts limited to 300 V to ground	3.6
(b) Insulated live parts limited to 150 V to ground	3.0

⑦Effectively grounded switch handles and supply or communication equipment cases (such as fire alarm boxes, control boxes, communication terminals, meters or similar equipment cases) may be mounted at a lower level for accessibility, provided such cases do not unduly obstruct a walkway.

NOTE: See also Rule 234J2c.

⑧Where the U.S. Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearances of that permit shall govern.

⑨For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level.

⑩For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.

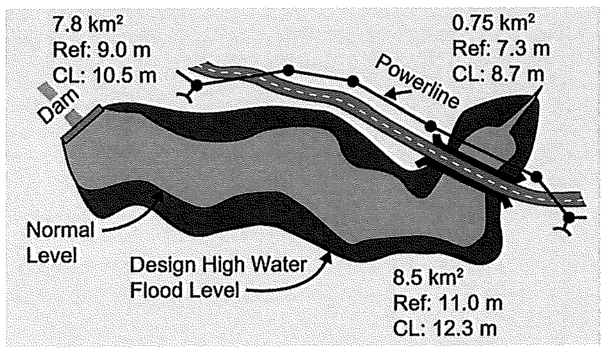
⑪The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1.6 km long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

⑫Where a bridge or other overwater obstruction restricts vessel height to less than the applicable reference height given in Table 232-3, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height for the area of the body of water over which the line crosses, except that the reduced clearance shall be not less than that required for the surface area on the line-crossing side of the obstruction.

EXAMPLE: If an 8.5 km^2 lake (over 8.0 km^2; reference height 11.0 m) consists of 7.8 km^2 (0.8 to 8.0 km^2; reference height 9.0 m) on one side of a bridge and 0.75 km^2 (0.08 to 8.0 km^2; reference height 7.3 m) on the other side of the bridge, the required line clearance must be not less than that required for an over 8.0 km^2 lake as required by Table 232-1 unless the bridge height above design high water is less than the reference dimension of 11.0 m.

If the line is placed on the 0.75 km^2 side and the bridge height above design high water is less than 11.0 m, but more than 7.3 m, the required line clearance is reduced from that required by a lake of over 8.0 km^2 by the difference between the bridge clearance and 11.0 m. If the bridge height above design high water is less than 7.3 m, the required clearance remains at that required for a 0.8 to 8.0 km^2 lake. See following figure.

Similarly, if the line is placed on the 7.8 km^2 side and the bridge height above design high water is less than 11.0 m, but more than 9.0 m, the required line clearance is reduced from that required by a lake of over 8.0 km^2 by the difference between the bridge clearance and 11.0 m. If the bridge height above design high water is less than 9.0 m, the required clearance remains at that required for a 0.8 to 8.0 km^2 lake.



Power line on small lake side of bridge

ft

Table 232-2— Vertical clearance of equipment cases, support arms, platforms, braces and unguarded rigid live parts above ground, roadway, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.
See Rules 232A, 232B2, 232B3, 232C1a, and 232D4.)

Nature of surface below	Nonmetallic or effectively grounded support arms, switch handles, platforms, braces, and equipment cases (ft)	Unguarded rigid live parts of 0 to 750 V and ungrounded cases that contain equipment connected to circuits of not more than 750 V (ft)	Unguarded rigid live parts of over 750 V to 22 kV and ungrounded cases that contain equipment connected to circuits of over 750 V to 22 kV (ft)
1. Where rigid parts overhang			
a. Roads, streets, and other areas subject to truck traffic [4]	15.0	16.0	18.0
b. Driveways, parking lots, and alleys	15.0	16.0 [6]	18.0
c. Other areas traversed by vehicles such as cultivated, grazing, forest, and orchard lands, industrial areas, commercial areas, etc. [3]	15.0 [7]	16.0	18.0
d. Spaces and ways subject to pedestrians or restricted traffic only [5]	9.0 [7]	12.0 [1]	14.0
2. Where rigid parts are along and within the limits of highways or other road rights-of-way but do not overhang the roadway			
a. Roads, streets, and alleys	15.0 [7]	16.0	18.0
b. Roads where it is unlikely that vehicles will be crossing under the line	13.0 [7]	14.0 [2]	16.0
3. Water areas not suitable for sailboating or where sailboating is prohibited [8]	13.5	14.5	16.5
4. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of [8] [9] [10] [11] [12]			
a. Less than 20 acres	17.0	18.0	20.0
b. Over 20 to 200 acres	25.0	26.0	28.0
c. Over 200 to 2000 acres	31.0	32.0	34.0
d. Over 2000 acres	37.0	38.0	40.0

ft

Table 232-2— *(continued)*
Vertical clearance of equipment cases, support arms, platforms, braces and unguarded rigid live parts above ground, roadway, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 232A, 232B2, 232B3, 232C1a, and 232D4.)

Nature of surface below	Nonmetallic or effectively grounded support arms, switch handles, platforms, braces, and equipment cases (ft)	Unguarded rigid live parts of 0 to 750 V and ungrounded cases that contain equipment connected to circuits of not more than 750 V (ft)	Unguarded rigid live parts of over 750 V to 22 kV and ungrounded cases that contain equipment connected to circuits of over 750 V to 22 kV (ft)
5. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sail boats	Clearance aboveground shall be 5 ft greater than in 4 above, for the type of water areas served by the launching site		

NOTE: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2a of Appendix A.

①For insulated live parts limited to 150 V to ground, this value may be reduced to 10 ft.

②Where a supply line along a road is limited to 300 V to ground and is located relative to fences, ditches, embankments, etc., so that the ground under the line would not be expected to be traveled except by pedestrians, this clearance may be reduced to 12 ft.

③When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 14 ft.

④For the purpose of this rule, trucks are defined as any vehicle exceeding 8 ft in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

⑤Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding 8 ft in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

⑥This clearance may be reduced to the following values for driveways, parking lots, and alleys not subject to truck traffic:

	(ft)
(a) Insulated live parts limited to 300 V to ground	12
(b) Insulated live parts limited to 150 V to ground	10

⑦Effectively grounded switch handles and supply or communication equipment cases (such as fire alarm boxes, control boxes, communication terminals, meters, or similar equipment cases) may be mounted at a lower level for accessibility, provided such cases do not unduly obstruct a walkway.
NOTE: See also Rule 234J2c.

⑧Where the U.S. Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearances of that permit shall govern.

⑨For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level.

⑩For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.

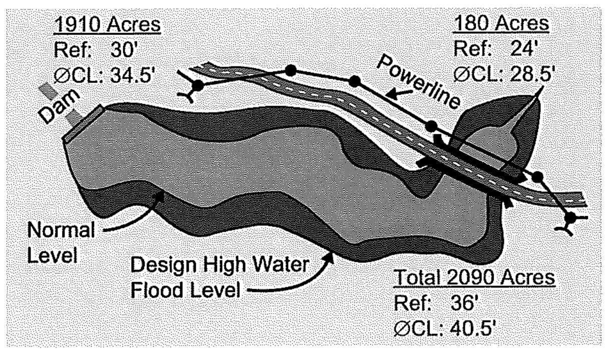
⑪The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1 mi long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

⑫Where a bridge or other overwater obstruction restricts vessel height to less than the applicable reference height given in Table 232-3, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height for the area of the body of water over which the line crosses, except that the reduced clearance shall be not less than that required for the surface area on the line-crossing side of the obstruction.

EXAMPLE: If a 2090 acre lake (over 2000 acres; reference height 36 ft) consists of 1910 acres (200 to 2000 acres; reference height 30 ft) on one side of a bridge and 180 acres (20 to 200 acres; reference height 24 ft) on the other side of the bridge, the required line clearance must be not less than that required for an over 2000 acre lake as required by Table 232-1 unless the bridge height above design high water is less than the reference dimension of 36 ft.

If the line is placed on the 180 acre side and the bridge height above design high water is less than 36 ft, but more than 24 ft, the required line clearance is reduced from that required by a lake of over 2000 acres by the difference between the bridge clearance and 36 ft. If the bridge height above design high water is less than 24 ft, the required clearance remains at that required for a 20 to 200 acre lake. See following figure.

Similarly, if the line is placed on the 1910 acre side and the bridge height above design high water is less than 36 ft, but more than 30 ft, the required line clearance is reduced from that required by a lake of over 2000 acres by the difference between the bridge clearance and 36 ft. If the bridge height above design high water is less than 30 ft, the required clearance remains at that required for a 200 to 2000 acre lake.



Power line on small lake side of bridge

Table 232-3—Reference heights
(See Rule 232D2.)

Nature of surface underneath lines	(m)	(ft)
a. Track rails of railroads (except electrified railroads using overhead trolley conductors) ①	6.7	22
b. Streets, alleys, roads, driveways, and parking lots	4.3	14
c. Spaces and ways subject to pedestrians or restricted traffic only ②	3.0	10
d. Other land, such as cultivated, grazing, forest, or orchard, that is traversed by vehicles	4.3	14
e. Water areas not suitable for sailboating or where sailboating is prohibited	3.8	12.5
f. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with unobstructed surface area ③ ④		
(1) Less than 0.08 km^2 (20 acres)	4.9	16
(2) Over 0.08 to 0.8 km^2 (20 to 200 acres)	7.3	24
(3) Over 0.8 to 8 km^2 (200 to 2000 acres)	9.0	30
(4) Over 8 km^2 (2000 acres)	11.0	36
g. In public or private land and water areas posted for rigging or launching sailboats, the reference height shall be 1.5 m (5 ft) greater than in f above, for the type of water areas serviced by the launching site		

①See Rule 234I for the required horizontal and diagonal clearances to rail cars.

②Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding 2.45 m (8 ft) in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

③For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level. For other waters, the surface area shall be that enclosed by its annual high-water mark, and clearances shall be based on the normal flood level. The clearances over rivers, streams, and canals shall be based upon the largest surface area of any 1600 m (1 mi) long segment that includes the crossing. The clearance over a canal or similar waterway providing access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

④Where an overwater obstruction restricts vessel height to less than the applicable reference height, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height, except that the reduced clearance shall not be less than that required for the surface area on the line-crossing side of the obstruction.

Table 232-4—Electrical component of clearance in Rule 232D3a

[This clearance shall be increased at the rate of 1% per 100 m (330 ft) in excess of 450 m (1500 ft) above mean sea level.
Increase clearance to limit electrostatic effects in accordance with Rules 232A and 232D3c.]

Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Switching surge (kV)	Electrical component of clearance	
			(m)	(ft)
242	3.54 or less	700 or less	2.17 ①	7.1 ①
362	2.37 or less	700 or less	2.17 ①	7.2 ①
550	1.56 or less	700 or less	2.17 ①	7.2 ①
	1.90	853	3.1	9.9
	2.00	898	3.3	10.8
	2.20	988	3.9	12.7
	2.40	1079	4.5	14.6
	2.60	1168	5.1	16.7
800	1.60	1045	4.3	13.9
	1.80	1176	5.2	16.9
	2.00	1306	6.2	20.1
	2.10 or more	1372 or more	6.7 ②	21.9 ②

①Shall be not less than that required by Rule 232D4, including the altitude correction for lines above 1000 m (3300 ft) elevation as specified in Rule 232C1b.

②Shall be not less than that required by Rules 232A and 232B.

233. Clearances between wires, conductors, and cables carried on different supporting structures

A. General

Crossings should be made on a common supporting structure, where practical. In other cases, the clearance between any two crossing or adjacent wires, conductors, or cables carried on different supporting structures shall be not less than that required by Rules 233B and 233C at any location in the spans. The clearance shall be not less than that required by application of a clearance envelope developed under Rule 233A2 to the positions on or within conductor movement envelopes developed under Rule 233A1 at which the two wires, conductors, or cables would be closest together. For purposes of this determination, the relevant positions of the wires, conductors, or cables on or within their respective conductor movement envelopes are those that can occur when (1) both are simultaneously subjected to the same ambient air temperature and wind loading conditions, and (2) each is subjected individually to the full range of its icing conditions and applicable design electrical loading.

Figure 233-1 is a graphical illustration of the application of Rule 233A. Alternate methods that ensure compliance with these rules may be used.

1. Conductor movement envelope

   a. Development

      The conductor movement envelope shall be developed from the locus of the most displaced conductor positions defined below and shown in Figure 233-2:

      (1) 15 °C (60 °F), no wind displacement, at both initial and final sag (conductor positions A and C).

      (2) With the wire, conductor, or cable displaced from rest by a 290 Pa (6 lb/ft^2) wind at both initial and final sag at 15 °C (60 °F). The displacement of the wire, conductor, or cable shall include deflection of suspension insulators and flexible structures (conductor positions B and D).

      (3) Final sag at one of the following loading conditions, whichever produces the largest sag (conductor position E):

         (a) 50 °C (120 °F), no wind displacement,

         (b) The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C (120 °F), with no wind displacement, or

         (c) 0 °C (32 °F), no wind displacement, with radial thickness of ice, if any, specified in Table 230-1 for the zone concerned.

   b. Sag increase

      No sag increase for either high operating temperatures or ice loading is required for trolley and electrified railroad contact conductors. Rule 233A1a(3) does not apply to these conductors.

2. Clearance envelope

   The clearance envelope shown in Figure 233-3 shall be determined by the horizontal clearance (H) required by Rule 233B and the vertical clearance (V) required by Rule 233C.

B. Horizontal clearance

1. Clearance requirements

   The horizontal clearance between adjacent wires, conductors, or cables carried on different supporting structures shall be not less than 1.50 m (5.0 ft). For voltages between the wires, conductors, or cables exceeding 22 kV, additional clearance of 10 mm (0.4 in) per kV in excess of 22 kV shall be provided. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

   The voltage between line conductors of different circuits shall be the greater of the following:

   (1) The phasor difference between the conductors involved

   NOTE: A phasor relationship of 180° is considered appropriate where the actual phasor relationship is unknown.

   (2) The phase-to-ground voltage of the higher-voltage circuit

   EXCEPTION: The horizontal clearance between anchor guys of different supporting structures may be reduced to 150 mm (6 in) and may be reduced to 600 mm (2 ft) between other guys, span wires, and neutral conductors meeting Rule 230E1.

2. For voltages exceeding 50 kV, the additional clearance specified in Rule 233B1 shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level.

3. Alternate clearances between conductors of different circuits where one or both circuits exceed 98 kV ac to ground or 139 kV dc to ground

   The clearances specified in Rule 233B1 may be reduced for circuits with known switching-surge factors, but shall be not less than the alternate clearance derived from the computations required in Rules 235B3a and 235B3b.

C. Vertical clearance

1. Clearance requirements

The vertical clearance between any crossing or adjacent wires, conductors, or cables carried on different supporting structures shall be not less than that shown in Table 233-1.

EXCEPTION: No vertical clearance is required between wires, conductors, or cables that are electrically interconnected at the crossing.

2. Voltages between the wires, conductors, or cables exceeding 22 kV

   a. Where the voltage between the conductors involved exceeds 22 kV, the clearance given in Table 233-1 shall be increased 10 mm (0.4 in) per kV in excess of 22 kV. The phasor difference voltage shall be computed using the maximum operating voltage if above 50 kV and nominal voltage if below 50 kV, of the respective circuits.

      The voltage between line conductors of different circuits shall be the greater of the following:

      (1) The phasor difference between the conductors involved

      NOTE: A phasor relationship of 180° is considered appropriate where the actual phasor relationship is unknown.

      (2) The phase-to-ground voltage of the higher-voltage circuit

      EXCEPTION 1: Where the voltage of either circuit exceeds 98 kV ac to ground or 139 kV dc to ground and the switching-surge factor is known, clearances less than those required above are permitted. (See Rule 233C3.)

      EXCEPTION 2: For voltages exceeding 470 kV, the vertical clearance shall be determined by the method given in Rule 233C3.

   b. For voltages exceeding 50 kV, the additional clearance specified in Rule 233C2a shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level.

3. Alternate clearances for voltage exceeding 98 kV ac to ground or 139 kV dc to ground

   The clearances specified in Rules 233C1 and 233C2 may be reduced where the higher-voltage circuit has a known switching-surge factor, but shall be not less than the alternate clearance, which is computed by adding the reference height from Rule 233C3a to the electrical component of clearance from Rule 233C3b. For these computations, communication conductors and cables, guys, messengers, neutral conductors meeting Rule 230E1, and supply cables meeting Rule 230C1 shall be considered at zero voltage.

   a. Reference heights

      The reference height shall be selected from Table 233-3.

   b. Electrical component of clearance

      (1) The electrical component (D) shall be computed using the following equations. Selected values of D are listed in Table 233-2.

$$D = 1.00\left[\frac{[V_H \cdot (PU) + V_L]a}{500K}\right]^{1.667} bc \quad \text{(m)}$$

$$D = 3.28\left[\frac{[V_H \cdot (PU) + V_L]a}{500K}\right]^{1.667} bc \quad \text{(ft)}$$

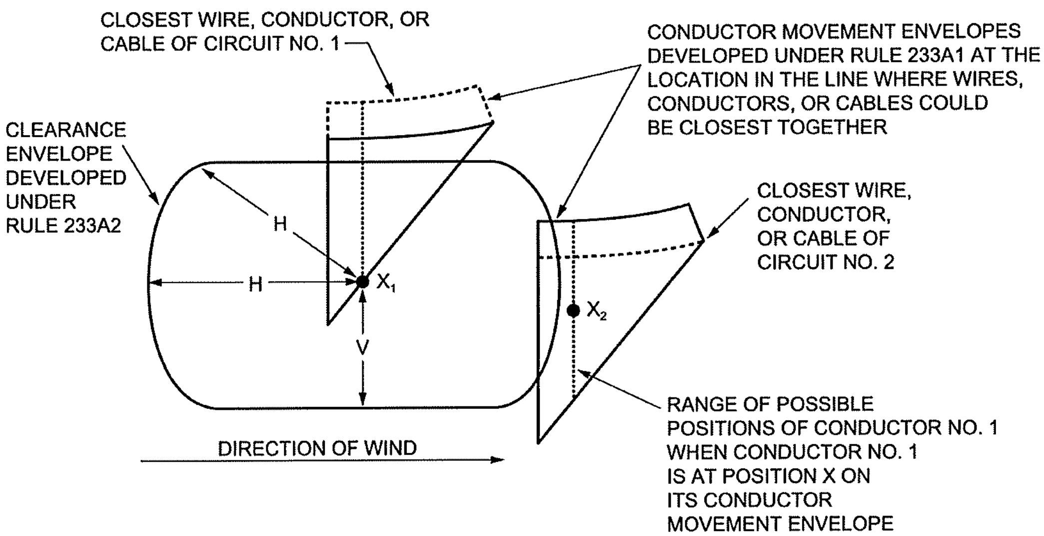
where

V_H = higher-voltage circuit maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts
V_L = lower-voltage circuit maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts
PU = higher-voltage circuit maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater
a = 1.15, the allowance for three standard deviations
b = 1.03, the allowance for nonstandard atmospheric conditions
c = 1.2, the margin of safety
K = 1.4, the configuration factor for conductor-to-conductor gap

(2) The value of D calculated by Rule 233C3b(1) shall be increased 3% for each 300 m (1000 ft) in excess of 450 m (1500 ft) above mean sea level.

c. Limit

The alternate clearance shall be not less than the clearance required by Rules 233C1 and 233C2 with the lower-voltage circuit at ground potential.



NOTE: In this illustration, Conductor No. 2 is closest at position X_2 to Conductor No. 1, where the latter is at position X_1.

Figure 233-1—Use of clearance envelope and conductor movement envelopes to determine applicable clearance

m

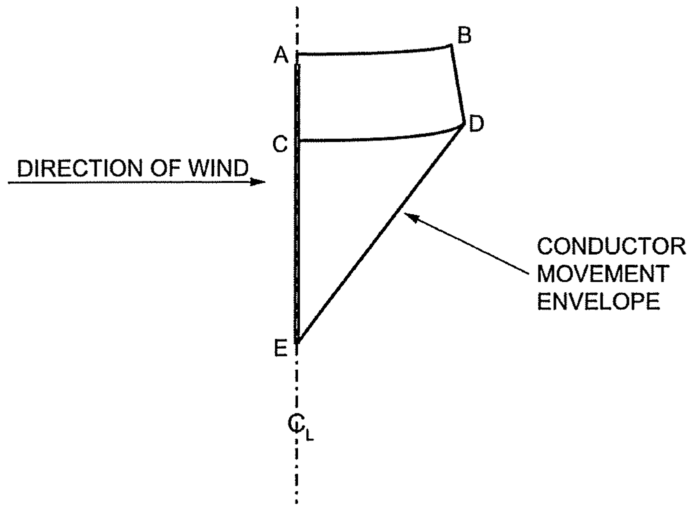


Figure 233-2—Conductor movement envelope

Point	Conductor temperature	Sag	Ice loading	Wind displacement ①
A	15 °C ⑤	Initial	None	None
B	15 °C ⑤	Initial	None	290 Pa
C	15 °C ⑤	Final	None	None
D	15 °C ⑤	Final	None	290 Pa
E_1 ③ ④	The greater of 50 °C or maximum operating temperature	Final	None	None
E_2 ③ ④	0 °C	Final	As applicable	None

①The direction of the wind shall be that which produces the minimum distance between conductors. The displacement of the wires, conductors, or cables includes the deflection of suspension insulators and flexible structures.
②Not used in this edition.
③Point E shall be determined by whichever of the conditions described under E_1 and E_2 produces the greatest sag.
④Line D–E shall be considered to be straight unless the actual concavity characteristics are known.
⑤When one conductor movement envelope is lower than that of the other conductor, the lower envelope shall be developed with points A, B, C, and D at a conductor temperature equal to the ambient temperature used in determining E of the upper conductor movement envelope.

ft

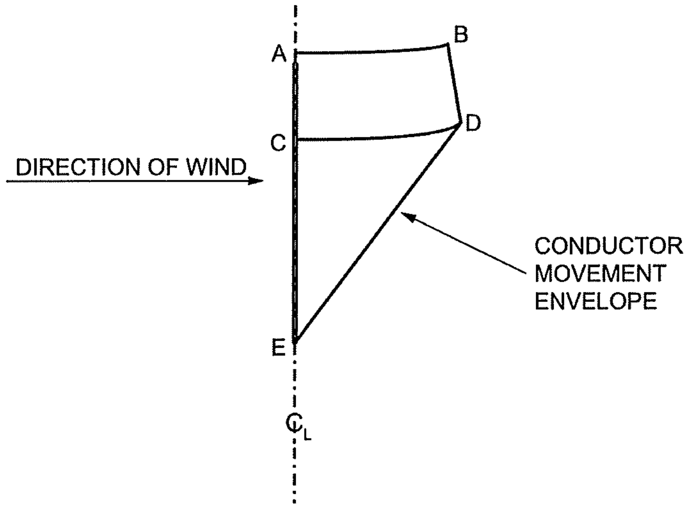


Figure 233-2—Conductor movement envelope

Point	Conductor temperature	Sag	Ice loading	Wind displacement ①
A	60 °F ⑤	Initial	None	None
B	60 °F ⑤	Initial	None	6 lb/ft^2
C	60 °F ⑤	Final	None	None
D	60 °F ⑤	Final	None	6 lb/ft^2
E_1 ③ ④	The greater of 120 °F or maximum operating temperature	Final	None	None
E_2 ③ ④	32 °F	Final	As applicable	None

①The direction of the wind shall be that which produces the minimum distance between conductors. The displacement of the wires, conductors, or cables includes the deflection of suspension insulators and flexible structures.
②Not used in this edition.
③Point E shall be determined by whichever of the conditions described under E_1 and E_2 produces the greatest sag.
④Line D–E shall be considered to be straight unless the actual concavity characteristics are known.
⑤When one conductor movement envelope is lower than that of the other conductor, the lower conductor envelope shall be developed with points A, B, C, and D at a conductor temperature equal to the ambient temperature used in determining E of the upper conductor movement envelope.

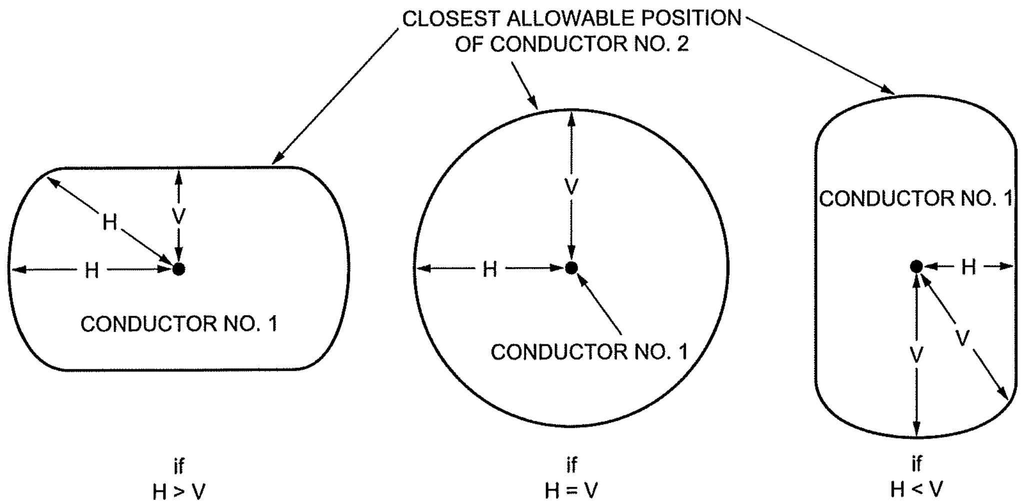


Figure 233-3—Clearance envelope

m

Table 233-1— Vertical clearance between wires, conductors, and cables carried on different supporting structures

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 233A, 233C1 and 233C2a.)

Lower level	Upper level				
	Effectively grounded communication guys[7], span wires and messengers, communication conductors and cables (m)	Effectively grounded supply guys[7], span wires and messengers, neutral conductors meeting Rule 230E1, and overhead shield/ surge-protection wires (m)	Supply cables meeting Rule 230C1, and supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (m)	Open supply conductors 0 to 750 V[6], and supply cables over 750 V meeting Rule 230C2 or 230C3 (m)	Open supply conductors over 750 V to 22 kV (m)
1. Effectively grounded supply guys[7], span wires and messengers, neutral conductors meeting Rule 230E1, and overhead shield/surge-protection wires	0.60 [1] [2]	0.60 [1] [2]	0.60 [2]	0.60	0.60
2. Effectively grounded communication guys[7], span wires and messengers; communication conductors and cables	0.60 [1] [2]	0.60 [1]	0.60	1.20 [8]	1.50 [5]
3. Supply cables meeting Rule 230C1, and supply cables of 0 to 750 V meeting Rule 230C2 or 230C3	0.60	0.60	0.60	0.60	0.60
4. Open supply conductors, 0 to 750 V[6]; supply cables over 750 V meeting Rule 230C2 or 230C3	1.20 [9]	0.60	0.60	0.60	0.60
5. Open supply conductors, 750 V to 22 kV	1.50 [5] [9]	0.60	0.60 [9]	0.60 [9]	0.60
6. Trolley and electrified railroad contact conductors and associated span and messenger wires	1.20 [3]	1.20 [3]	1.20 [3]	1.20 [3] [4]	1.80

①No clearance is specified between guys or span wires that are electrically interconnected.

②The clearance of communication conductors and their guy, span, and messenger wires from each other in locations where no other classes of conductors are involved may be reduced by mutual consent of the parties concerned, except for fire-alarm conductors and conductors used in the operation of railroads.

③Trolley and electrified railroad contact conductors of more than 750 V should have at least 1.80 m of clearance. This clearance should also be provided over lower-voltage trolley and electrified railroad contact conductors unless the crossover conductors are beyond reach of a trolley pole leaving the trolley-contact conductor or are suitably protected against damage from trolley poles leaving the trolley-contact conductor.
④Trolley and electrified railroad feeders are exempt from this clearance requirement for contact conductors if they are of the same nominal voltage and of the same system.
⑤This clearance may be reduced to 1.20 m where supply conductors of 750 V to 8.7 kV cross a communication line more than 6 ft horizontally from a communications structure.
⑥ Does not include neutral conductors meeting Rule 230E1.
⑦These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
⑧This clearance may be reduced to 0.60 m for supply service drops.
⑨In general, this type of crossing is not recommended.

ft

Table 233-1—
Vertical clearance between wires, conductors, and cables carried on different supporting structures

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 233A, 233C1 and 233C2a.)

Lower level	Upper level				
	Effectively grounded communication guys ⑦, span wires and messengers, communication conductors and cables (ft)	Effectively grounded supply guys ⑦, span wires and messengers, neutral conductors meeting Rule 230E1, and overhead shield/ surge-protection wires (ft)	Supply cables meeting Rule 230C1, and supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (ft)	Open supply conductors 0 to 750 V ⑥, and supply cables over 750 V meeting Rule 230C2 or 230C3 (ft)	Open supply conductors over 750 V to 22 kV (ft)
1. Effectively grounded supply guys⑦, span wires and messengers, neutral conductors meeting Rule 230E1, and overhead shield/ surge-protection wires	2.0 ① ②	2.0 ① ②	2.0 ②	2.0	2.0
2 Effectively grounded communication guys⑦, span wires and messengers; communication conductors and cables	2.0① ②	2.0 ①	2.0	4.0 ⑧	5.0 ⑤
3. Supply cables meeting Rule 230C1, and supply cables of 0 to 750 V meeting Rule 230C2 or 230C3	2.0	2.0	2.0	2.0	2.0
4. Open supply conductors, 0 to 750 V ⑥; supply cables over 750 V meeting Rule 230C2 or 230C3	4.0 ⑨	2.0	2.0	2.0	2.0

m

Table 233-2—
Clearance between supply wires, conductors, and cables in Rules 233A and 233C3b(1)

(This clearance shall be increased 3% for each 300 m in excess of 450 m above mean sea level.)

Higher-voltage circuit		Lower-voltage circuit						
Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Clearance at maximum operating voltage phase to phase (kV)						
		121 kV (m)	145 kV (m)	169 kV (m)	242 kV (m)	362 kV (m)	550 kV (m)	800 kV (m)
242	3.3 or less	1.78 ①	1.84	1.91	2.16			
362	2.4	2.48 ①	2.48 ①	2.48 ①	2.48 ①	2.86		
	2.6	2.48 ①	2.48 ①	2.48 ①	2.67	3.2		
	2.8	2.49	2.58	2.67	3.0	3.5		
	3.0	2.76 ①	2.86 ①	3.0	3.3	3.8		
550	1.8	3.6 ①	3.6 ①	3.6 ①	3.6 ①	3.6 ①	4.2	
	2.0	3.6 ①	3.6 ①	3.6 ①	3.6 ①	3.8 ①	4.7	
	2.2	3.6 ①	3.6 ①	3.6 ①	3.8	4.3	5.2	
	2.4	3.8	3.9	4.0	4.3	4.8	5.8	
	2.6	4.1 ②	4.2 ②	4.4 ②	4.8 ②	5.4	6.3	
800	1.6	5.0 ①	5.0 ①	5.0 ①	5.0 ①	5.0 ①	5.6	6.9
	1.8	5.0 ①	5.0 ①	5.0 ①	5.0 ①	5.4	6.4	7.8
	2.0	5.0 ①	5.2	5.3	5.6	6.3	7.3	8.7
	2.2	5.5 ②	5.7 ②	5.8 ②	6.2 ②	6.9 ②	8.0 ②	9.4 ②

①Shall be not less than that required by Rule 233C3c, including the altitude correction for lines above 1000 m (3300 ft) elevation as specified in Rule 233C2b.
②Need not be greater than the values specified in Rules 233C1 and 233C2.

ft

Table 233-2—
Clearance between supply wires, conductors, and cables in Rule 233A and 233C3b(1)
(This clearance shall be increased 3% for each 1000 ft in excess of 1500 ft above mean sea level.)

Higher-voltage circuit		Lower-voltage circuit						
Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Clearance at maximum operating voltage phase to phase (kV)						
		121 kV (ft)	145 kV (ft)	169 kV (ft)	242 kV (ft)	362 kV (ft)	550 kV (ft)	800 kV (ft)
242	3.3 or less	6.0 ①	6.1	6.3	7.1			
362	2.4	8.3 ①	8.3 ①	8.3 ①	8.3①	9.4		
	2.6	8.3 ①	8.3 ①	8.3 ①	8.8	10.3		
	2.8	8.3 ①	8.5	8.8	9.7	11.3		
	3.0	9.1	9.4	9.7	10.7	12.3		
550	1.8	11.9 ①	11.9 ①	11.9 ①	11.9 ①	11.9 ①	13.6	
	2.0	11.9 ①	11.9 ①	11.9 ①	11.9 ①	12.5	15.3	
	2.2	11.9 ①	11.9 ①	11.9 ①	12.4	14.1	17.0	
	2.4	12.2	12.6	12.9	14.0	15.8	18.8	
	2.6	13.5 ②	14.0 ②	14.4	15.6	17.5	20.7	
800	1.6	16.7 ①	16.7 ①	16.7 ①	16.7 ①	16.7	18.2	22.5
	1.8	16.7 ①	16.7 ①	16.7 ①	16.7 ①	17.7	20.9	25.4
	2.0	16.7 ①	16.8	17.2	18.4	20.4	23.7	28.5
	2.2	18.3 ②	18.8 ②	19.2 ②	20.6 ②	22.9 ②	26.6 ②	31.4 ②

①Shall be not less than that required by Rule 233C3c, including the altitude correction for lines above 1000 m (3300 ft) elevation as specified in Rule 233C2b.
②Need not be greater than the values specified in Rules 233C1 and 233C2.

Table 233-3—Reference heights
(See Rule 233C3a.)

Reference height	(m)	(ft)
(1) Supply lines	0	0
(2) Communication lines	0.60	2

234. Clearance of wires, conductors, cables, and equipment from buildings, bridges, rail cars, swimming pools, and other installations

A. Application

In each of Rules 234B, 234C, and 234D, horizontal clearance requirements are specified for two conditions: (1) the conductor without wind displacement (at rest), and (2) the conductor with wind displacement. In each case, the clearance requirements for both conditions shall be satisfied.

1. Vertical and horizontal clearances (no wind displacement)

The vertical and horizontal clearances specified in Rules 234B, 234C, 234D, 234E, 234F, and 234I apply under whichever conditions of the following conductor temperature and loading conditions produces the closest approach. Rules 234A1a, 234A1b, and 234A1c apply above and alongside subject installations; Rule 234A1d applies below and alongside subject installations.

a. 50 °C (120 °F), no wind displacement, final sag.

b. The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C (120 °F), no wind displacement, final sag.

c. 0 °C (32 °F), no wind displacement, final sag, with radial thickness of ice, if any, specified in Table 230-1 for the zone concerned.

d. The minimum conductor temperature for which the line is designed, no wind displacement, initial sag.

EXCEPTION: Vertical or lateral conductors or cables attached directly to the surface of a supporting structure in accordance with other rules are not subject to the provisions of this rule.

NOTE: The phase and neutral conductors of a supply line are normally considered separately when determining the sag of each due to temperature rise.

2. Horizontal clearances (with wind displacement)

Where consideration of horizontal displacement under wind conditions is required, the wires, conductors, or cables shall be considered to be displaced from rest toward the installation by a 290 Pa (6 lb/ft^2) wind at final sag at 15 °C (60 °F). The displacement of a wire, conductor or cable shall include deflection of suspension insulators. The displacement of a wire, conductor, or cable shall also include deflection of a flexible structure if the highest wire, conductor, or cable attachment is 18 m (60 ft) or more above grade.

EXCEPTION: Where the entire span is so close to a building, terrain feature, or other obstacle as to be sheltered from the wind flowing across the line in either direction, the wind pressure may be reduced to a 190 Pa (4 lb/ft^2) wind. Trees are not considered to shelter a line.

3. Transition between horizontal and vertical clearances

The horizontal clearance governs above the level of the roof or top of an installation to the point where the diagonal equals the vertical clearance requirement. Similarly, the horizontal clearance governs above or below projections from buildings, signs, or other installations to the point where the diagonal equals the vertical clearance requirement. From this point the transitional clearance shall equal the vertical clearance as shown in Figure 234-1(a) and

Figure 234-1(b). This rule should not be interpreted as restricting the installation of a trolley-contact conductor over the approximate center line of the track it serves.

EXCEPTION: When the horizontal clearance is greater than the vertical clearance, the vertical clearance governs beyond the roof or top of an installation, or projections from an installation, to the point where the diagonal equals the horizontal clearance requirement, as shown in Figure 234-1(c).

B. Clearances of wires, conductors, and cables from other supporting structures

Wires, conductors, or cables of one line passing near a lighting support, traffic signal support, a supporting structure of a second line, or intermediate poles in skip-span construction, without being attached thereto, shall have clearance from any part of such structure not less than the following:

NOTE: Skip-span construction: Lines where upper conductors are not attached to intermediate poles.

1. Horizontal clearances

a. A horizontal clearance, without wind, of not less than 1.50 m (5.0 ft) for voltages up to 22 kV.

EXCEPTION: For effectively grounded guys and messengers, insulated communication conductors and cables, neutrals meeting Rule 230E1, and cables of 300 V or less to ground meeting the requirements of Rule 230C1, 230C2, or 230C3, the horizontal clearance may be reduced to 900 mm (3 ft).

b. When the following conductors and cables are displaced from rest under the wind conditions of Rule 234A2, horizontal clearances from such conductors or cables to other supporting structures shall be not less than those shown below:

Conductor or cable	Horizontal clearance required when displaced by wind	
	(m)	(ft)
Open supply conductors, 0 to 750 V ①	1.1	3.5
230C2 cable, above 750 V	1.1	3.5
230C3 cable, above 750 V	1.1	3.5
Open supply conductors, over 750 V to 22 kV	1.4	4.5

①Does not include neutral conductors meeting Rule 230E1.

2. Vertical clearances

A vertical clearance of not less than 1.40 m (4.5 ft) for voltages up to 22 kV. *EXCEPTIONS 1* and *2* shall not be applied cumulatively.

EXCEPTION 1: For effectively grounded guys and messengers, insulated communication conductors and cables, and neutrals meeting Rule 230E1 and for cables of 300 V or less to ground meeting the requirements of Rule 230C1, 230C2, or 230C3, the vertical clearance may be reduced to 600 mm (2 ft).

EXCEPTION 2: The vertical clearances may be reduced by 600 mm (2 ft) if both of the following conditions are met:

(a) The wires, conductors, or cables above and the supporting structure of another line below are operated and maintained by the same utility

(b) Employees do not work above the top of the supporting structure unless:

(1) The upper circuit is de-energized and grounded per Rule 444D or temporarily insulated or repositioned, or

(2) Other equivalent measures are taken.

NOTE: Clearances of wires, conductors, and cables from adjacent line structure guy wires are given in Rule 233.

C. Clearances of wires, conductors, cables, and rigid live parts from buildings, signs, billboards, chimneys, radio and television antennas, tanks, flagpoles and flags, banners, and other installations except bridges

1. Vertical and horizontal clearances

a. Clearances

Unguarded or accessible wires, conductors, cables, or rigid live parts may be located adjacent to buildings, signs, billboards, chimneys, radio and television antennas, tanks, flagpoles and flags, banners, and other installations and any projections therefrom. The vertical and horizontal clearances of such rigid and nonrigid parts shall be not less than the values given in Table 234-1 when at rest under the conditions specified in Rule 234A1. These facilities may be installed beside, over or under buildings, building projections and other installations, as illustrated in Figure 234-1(a), Figure 234-1(b), and Figure 234-1(c).

b. Horizontal clearances under wind displacement conditions

When the following conductors and cables are displaced from rest under the wind conditions of Rule 234A2, horizontal clearances from such conductors or cables to buildings, signs, billboards, chimneys, radio and television antennas, flagpoles and flags, banners, and other installations shall be not less than those shown below:

Conductor or cable	Horizontal clearance required when displaced by wind	
	(m)	(ft)
Open supply conductors, 0 to 750 V ①	1.1	3.5
230C2 cable, above 750 V	1.1	3.5
230C3 cable, above 750 V	1.1	3.5
Open supply conductors, over 750 V to 22 kV	1.4	4.5

①Does not include neutral conductors meeting Rule 230E1.
See Footnotes 9 and 10 to Table 234-1.

2. Guarding of supply conductors and rigid live parts

Where the clearances set forth in Table 234-1 cannot be obtained, supply conductors and rigid live parts shall be guarded. Supply cables meeting Rule 230C1a are considered to be guarded within the meaning of this rule.

3. Supply conductors attached to buildings or other installations

Where the permanent attachment of supply conductors of any class to a building or other installation is necessary for an entrance, such conductors shall meet the following requirements over or along the installation to which the conductors are attached:

a. Energized service drop conductors, including splices and taps, shall be insulated or covered in accordance with the following:

(1) For 0 to 750V, Rule 230C or 230D

(2) For over 750 V, Rule 230C1

This rule does not apply to neutral conductors meeting Rule 230E1.

b. Conductors of more than 300 V to ground shall not be carried along or near the surface of the installation unless they are guarded or made inaccessible.

c. Wires or cables attached to and run along side the installation shall have clearances from the surface of the installation not less than 75 mm (3 in).

EXCEPTION: For open supply circuits of 0 to 750 V and supply cables of all voltages meeting Rule 230C1, 230C2, or 230C3, the clearance at the attachment points may be reduced to 25 mm (1 in). No clearance from the served structure is specified for such conductors anywhere else in the span where they are physically restrained by a suitable bracket from abrasion against the served structure.

d. Service-drop conductors, including drip loops shall have a clearance of not less than the following:

(1) 3.0 m (10 ft) vertical clearance from the highest point of readily accessible roofs, balconies, attached decks, fire escapes, or other attached structures over which they pass or to which they are attached.

EXCEPTION 1: For clearances above railings, walls, or parapets around balconies, decks, or roofs, use the clearances required for row 1b(1), Table 234-1. For such clearances where an outside stairway exists to provide access to such balconies, decks, or roofs, use the clearances required for row 2b(2), Table 234-1.

EXCEPTION 2: Where the voltage between conductors meeting Rule 230D does not exceed 300 V, or where the voltage of cables meeting Rule 230C2 or 230C3 does not exceed 750 V, or where the cable meets Rule 230C1, and the roof or balcony is not readily accessible, the clearance over the roof or balcony, including the drip loop shall be not less than either of the following:

(a) 900 mm (3 ft)

(b) 457 mm (18 in) for a horizontal distance of 1.8 m (6 ft) from an approved raceway or support located not more than 1.2 m (4 ft) from the edge of the roof and not less than 900 mm (3 ft) for the remainder of the horizontal distance that the cable or conductor passes over the roof or balcony

A roof, balcony, or similar structure is considered readily accessible to pedestrians if it can be casually accessed through a doorway, window, ramp, stairway, or permanently mounted ladder by a person, on foot, who neither exerts extraordinary physical effort nor employs tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its bottom rung is 2.45 m (8 ft) or more from the ground or other permanently installed accessible surface, or is otherwise equipped with barriers to inhibit climbing by unauthorized persons.

NOTE 1: See Figure 234-2.

NOTE 2: See Table 234-6.

(2) Not less than 900 mm (3 ft) in any direction from windows.

EXCEPTION 1: This does not apply to service-drop conductors meeting Rule 230C3 above the top level of a window.

EXCEPTION 2: This does not apply to windows that are not designed to open.

(3) Not less than 1.5 m (5 ft) horizontally from porches, decks, fire escapes, or other similarly attached structures.

(4) Not less than 900 mm (3 ft) vertical clearance below porches, decks, fire escapes, or similarly attached structures.

NOTE: See Rule 232 for clearances aboveground.

4. Communication conductors attached to buildings or other installations

Communication conductors and cables may be attached directly to buildings or other installations.

5. Ladder space

Where buildings or other installations exceed three stories [or 15 m (50 ft)] in height, overhead lines should be arranged where practical so that a clear space or zone at least 1.8 m (6 ft) wide will be left either adjacent to the building or beginning not over 2.45 m (8 ft) from the building to facilitate the raising of ladders where necessary for fire fighting.

EXCEPTION: This requirement does not apply where it is the unvarying rule of the local fire departments to exclude the use of ladders in alleys or other restricted places that are generally occupied by supply conductors and cables.

D. Clearance of wires, conductors, cables, and unguarded rigid live parts from bridges

1. Vertical and horizontal clearances

a. Clearances

Unguarded or accessible wires, conductors, cables, or rigid live parts may be located adjacent to or within a bridge structure. The vertical and horizontal clearances of such rigid and nonrigid parts shall be not less than the values given in Table 234-2 when at rest under the conditions specified in Rule 234A1, as illustrated in Figure 234-1(a) and Figure 234-1(b).

EXCEPTION: This rule does not apply to insulated communication cables, effectively grounded guys, span wires, and surge protection wires; neutrals meeting Rule 230E1; and supply cables meeting Rule 230C1.

b. Horizontal clearances under wind displacement conditions

When the following conductors and cables are displaced from rest under the wind conditions of Rule 234A2, horizontal clearances from such conductors or cables to bridges shall be not less than those shown below:

Conductor or cable	Horizontal clearance required when displaced by wind	
	(m)	(ft)
Open supply conductors, 0 to 750 V ①	1.1	3.5
230C2 cable, above 750 V	1.1	3.5
230C3 cable, above 750 V	1.1	3.5
Open supply conductors, over 750 V to 22 kV	1.4	4.5

①Does not include neutral conductors meeting Rule230E1.
See Footnotes 8 and 9 to Table 234-2.

2. Guarding trolley-contact conductors located under bridges

a. Where guarding is required

Guarding is required where the trolley-contact conductor is located so that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

b. Nature of guarding

Guarding shall consist of a substantial inverted trough of nonconducting material located above the contact conductor, or of other suitable means of limiting the likelihood of contact between the trolley support and the bridge structure.

E. Clearance of wires, conductors, cables, or unguarded rigid live parts installed over or near swimming areas with no wind displacement

1. Swimming pools

Where wires, conductors, cables, or unguarded rigid live parts are over in-ground or permanently installed aboveground swimming pools or the surrounding area, the clearances in any direction shall be not less than those shown in Table 234-3 and illustrated in Figure 234-3(a), Figure 234-3(b), and Figure 234-3(c). Vertical clearances for permanently installed aboveground pools shall be measured from the highest location where people can stand.

NOTE 1: Permanently installed aboveground pools are ones that are not intended to be moved or routinely disassembled.

NOTE 2: For NESC clearance purposes, spas (including whirlpools, hot-tubs, or other similar installations not suitable for swimming) are not considered as swimming pools covered by Rule 234E, Table 234-3. Note that this rule and table refer to swimming areas and swimming pools. Table 234-3 clearances allow for use of skimmer and rescue poles.

Spas, etc., not suitable for swimming, are usually installed as part of a building or as a similar installation. Clearances for such installations are found in Table 234-1. Vertical clearance should be from the highest point of the installation upon which people can stand. See row 1, Buildings, in Table 234-1 for installations that are part of buildings, such as a raised spa on an open deck. See row 2, other installations, in Table 234-1 for free-standing installations.

For portable wading pools, see Table 234-1, row 5.

EXCEPTION 1: This rule does not apply to a pool fully enclosed by a solid or screened permanent structure.

EXCEPTION 2: This rule does not apply to communication conductors and cables, effectively grounded surge-protection wires, neutral conductors meeting Rule 230E1, guys and messengers, supply cables meeting Rule 230C1, and supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 when these facilities are 3 m (10 ft) or more horizontally from the edge of the pool, diving platform, diving tower, water slide, or other fixed, pool-related structures.

2. Beaches and waterways restricted to swimming

   Where rescue poles are used by lifeguards at supervised swimming beaches, the vertical and horizontal clearances shall be not less than those shown in Table 234-3. Where rescue poles are not used, the clearances shall be as specified in Rule 232.

3. Waterways subject to water skiing

   The vertical clearance shall be the same as that specified in Rule 232.

F. Clearances of wires, conductors, cables, and rigid live parts from grain bins

1. Grain bins loaded by permanently installed augers, conveyers, or elevator systems

   All portions of grain bins that are expected to be loaded by the use of a permanently installed auger, conveyer, or elevator system shall be considered as a building or other installation under Rule 234C for the purpose of determining appropriate clearances of wires, conductors, cables, and rigid live parts. In addition, the following clearances shall also apply without wind displacement. See Figure 234-4(a).

   a. A clearance of not less than 5.5 m (18 ft) in all directions above the grain bin shall be maintained from each probe port in the grain bin roof for all wires, conductors, and cables.

   b. A horizontal clearance of not less than 4.6 m (15 ft) shall be maintained between grain bins and open supply conductors, 0 to 22 kV. This clearance does not apply to a neutral conductor meeting Rule 230E1.

2. Grain bins loaded by portable augers, conveyers, or elevators (with no wind displacement)

   a. The clearance of wires, conductors, cables, and rigid live parts from grain bins that are expected to be loaded by the use of a portable auger, conveyer, or elevator shall be not less than the values illustrated in Figure 234-4(b).

      EXCEPTION: Clearances of the following items on the nonloading side of grain bins shall be not less than those required by Rule 234C for clearances from buildings:

      (a) Support arms; effectively grounded equipment cases

      (b) Insulated communication conductors and cables, messengers, surge-protection wires, effectively grounded guys, neutral conductors meeting Rule 230E1, and supply cables meeting Rule 230C1

      (c) Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3

   b. Any side of a grain bin is considered to be a nonloading side if it is so designated, or if it is so closely abutting another structure or obstruction, or so close to a public road or other right-of-way that a portable auger, conveyor, or elevator is not reasonably anticipated to be used over that side or portion to fill the grain bin.

   c. Where an agreement excludes the use of portable augers, conveyors, or elevators from a designated portion of a grain bin, such portion is considered to be a nonloading side.

G. Additional clearances for voltages exceeding 22 kV for wires, conductors, cables, and unguarded rigid live parts of equipment

Greater clearances than specified in Rules 234B, 234C, 234D, 234E, 234F, and 234J shall be provided where required as follows:

1. For voltages between 22 and 470 kV, the clearance specified in Rules 234B, 234C, 234D, 234E, 234F, and 234J shall be increased at the rate of 10 mm (0.4 in) per kV in excess of 22 kV. For voltages exceeding 470 kV, the clearance shall be determined by the method given in Rule 234H. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

   EXCEPTION: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required above are permitted for systems with known maximum switching-surge factor. (See Rule 234H.)

2. For voltages exceeding 50 kV, the additional clearance specified in Rule 234G1 shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level.

3. For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means, as required, to limit the steady-state current due to electrostatic effects to 5 mA, rms, if an ungrounded metal fence, building, sign, billboard, chimney, radio or television antenna, tank or other installation, or any ungrounded metal attachments thereto, were short-circuited to ground. For this determination, the conductor shall be at a final sag at 50 °C (120 °F).

H. Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 234B, 234C, 234D, 234E, 234F, 234G, and 234J may be reduced for circuits with known switching-surge factors, but shall be not less than the alternate clearance, which is computed by adding the reference distance from Rule 234H2 to the electrical component of clearance from Rule 234H3.

1. Sag conditions of line conductors

   The vertical, horizontal, and diagonal clearances shall be maintained under the conductor temperature and loading conditions given in Rule 234A.

2. Reference distances

   The reference distance shall be selected from Table 234-5.

3. Electrical component of clearance

   a. The electrical component (D) shall be computed using the following equations. Selected values of D are listed in Table 234-4.

$$D = 1.00\left[\frac{V \cdot (PU) \cdot a}{500K}\right]^{1.667} bc \quad \text{(m)}$$

$$D = 3.28\left[\frac{V \cdot (PU) \cdot a}{500K}\right]^{1.667} bc \quad \text{(ft)}$$

where

V = maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

c = the margin of safety:

1.2 for vertical clearances

1.0 for horizontal clearances

K = 1.15, the configuration factor for conductor-to-plane gap

b. The value of D shall be increased 3% for each 300 m (1000 ft) in excess of 450 (1500 ft) above mean sea level.

4. Limit

The alternate clearance shall be not less than the clearance of Rule 234B, Table 234-1, Table 234-2, or Table 234-3, as applicable, computed for 98 kV ac rms to ground by Rule 234G1.

I. Clearance of wires, conductors, and cables to rail cars

Where overhead wires, conductors, or cables run along railroad tracks, the clearance in any direction shall be not less than that shown in Figure 234-5. The values of V and H are as defined as follows:

V = vertical clearance from the wire, conductor, or cable above the top of the rail as specified in Rule 232 minus 6.1 m (20 ft), the assumed height of the rail car

H = horizontal clearance from the wire, conductor, or cable to the nearest rail, which is equal to the required vertical clearance above the rail minus 4.6 m (15 ft) as computed by the lesser of the following:

1. Rules 232B1 and 232C1
2. Rule 232D

These clearances are computed for railroads handling standard rail cars as common carriers in interchange service with other railroads. Where wires, conductors, or cables run along mine, logging, and similar railways that handle only cars smaller than standard freight cars, the value of H may be reduced by one-half the difference between the width of a standard rail car [3.3 m (10 ft, 8 in)] and the width of the narrower car.

J. Clearance of equipment mounted on supporting structures

1. Clearance to unguarded rigid live parts of equipment

The horizontal and vertical clearances of unguarded rigid live parts such as potheads, transformer bushings, surge arresters, and short lengths of supply conductors connected thereto, which are not subject to variation in sag, shall be not less than those required by Rule 234C or 234D, as applicable.

2. Clearance to equipment cases

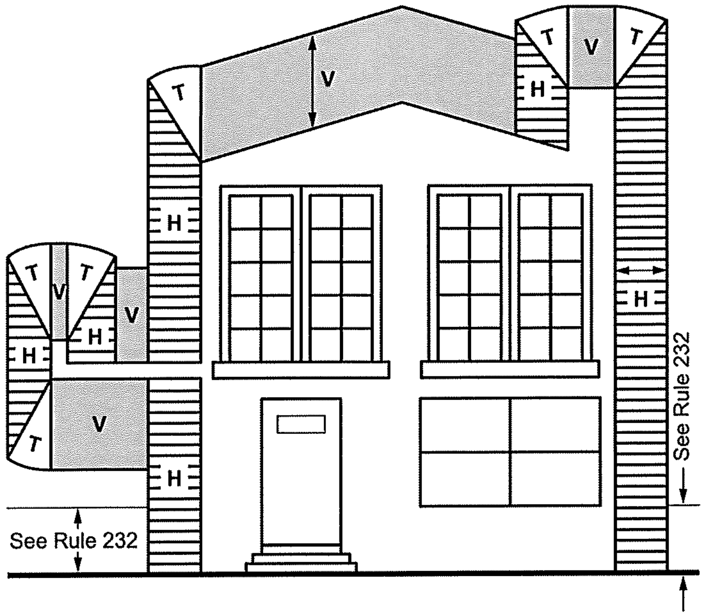
Equipment shall be mounted so that clearances are not less than that given by Rules 234J2a, 234J2b, and 234J2c.

a. Effectively grounded equipment cases may be located on or adjacent to buildings, bridges, or other structures provided that clearances for unguarded rigid live parts of such equipment, as specified in Rule 234J1, are maintained.

b. Equipment cases that are not effectively grounded shall be located so that the clearances of Rule 234C or 234D, as applicable, are maintained.

c. Equipment cases shall be located so as not to serve as a means of approach to unguarded rigid live parts by unqualified persons.

NOTE: Rule 234J is not subject to the loading conditions of Rule 234A.



LEGEND

Regions Where Conductors Are Prohibited	Controlling Clearance
H	Horizontal
V	Vertical
T	Transitional = Vertical (Arc)

Figure 234-1(a)—Clearance diagram for building

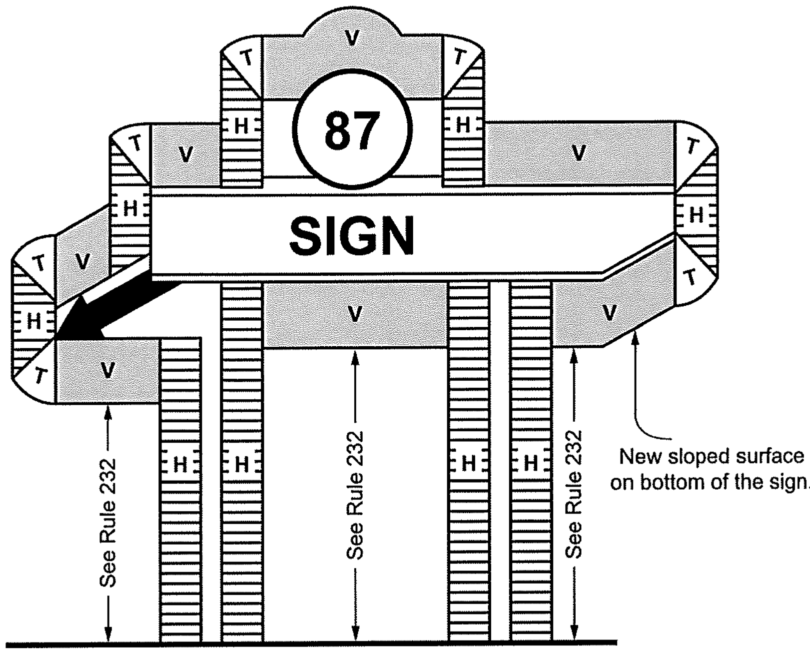


Figure 234-1(b)—Clearance diagram for other structures

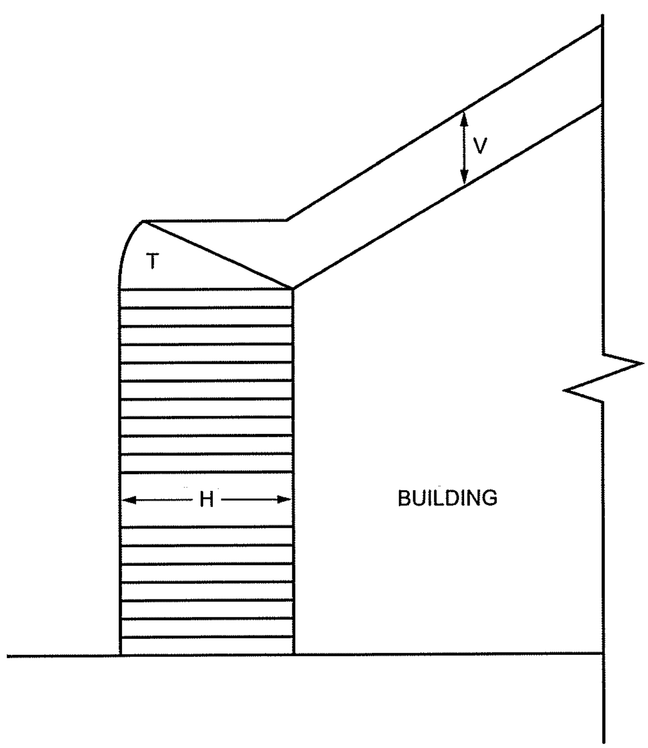


Figure 234-1(c)—Transitional clearance when H is greater than V

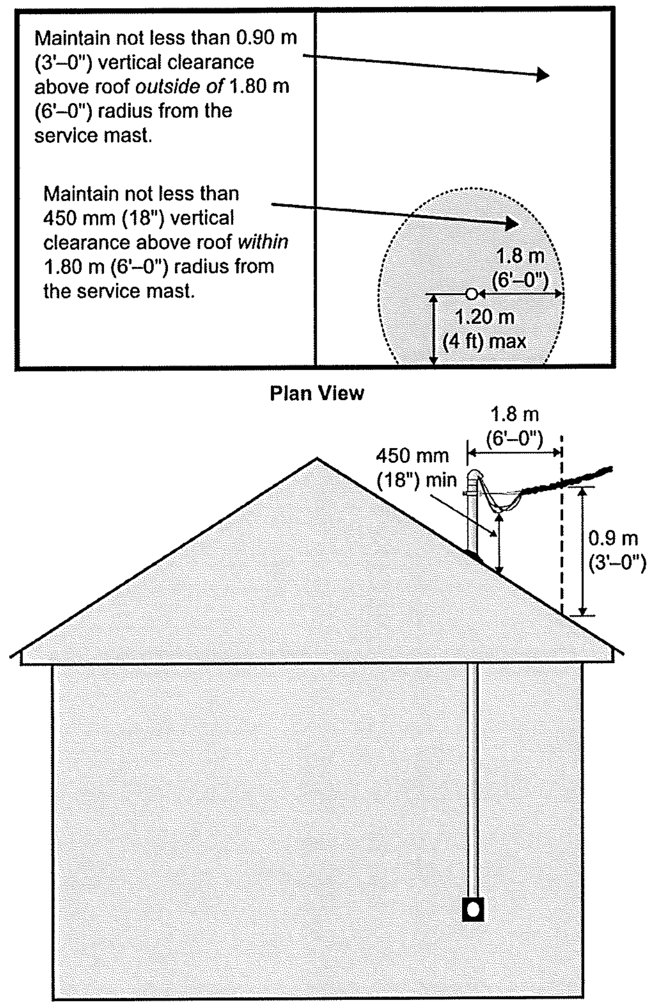


Figure 234-2—Clearances of service drop terminating on support mast

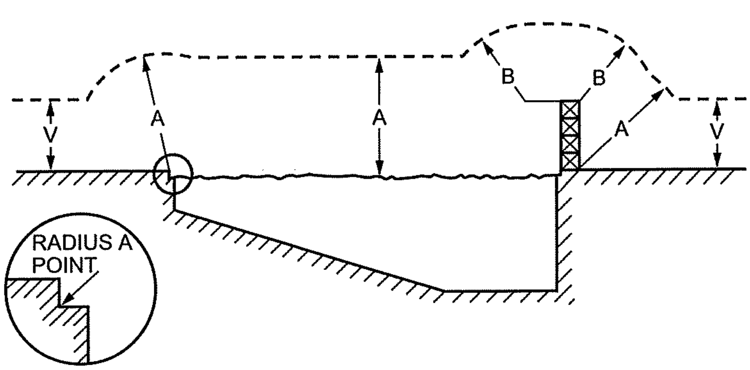


Figure 234-3(a)—Swimming pool clearances

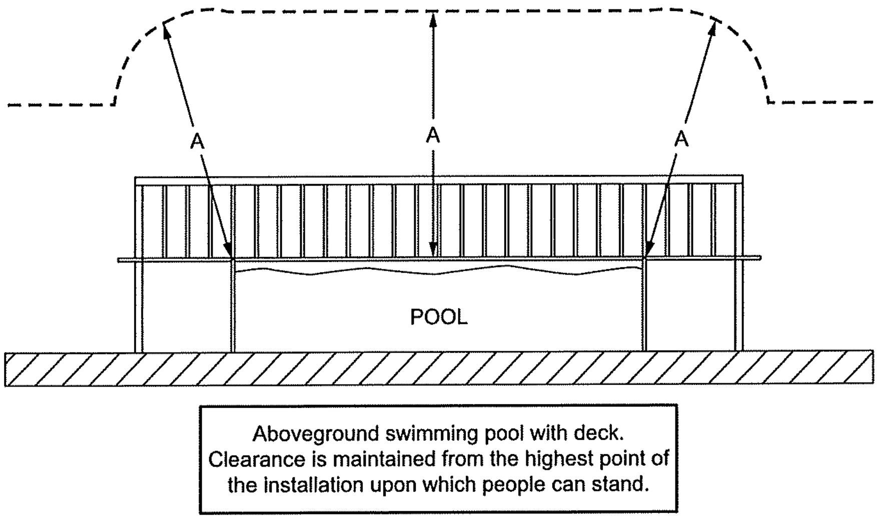


Figure 234-3(b)—Aboveground swimming pool with deck

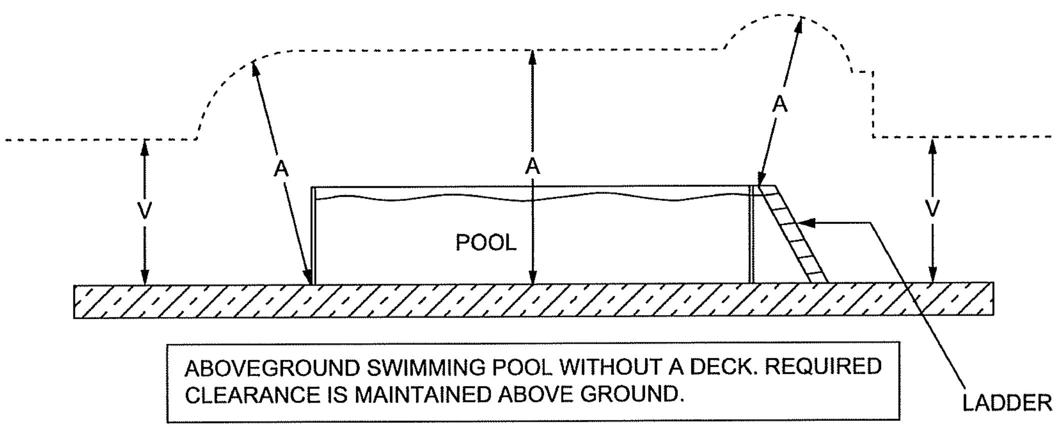


Figure 234-3(c)—Aboveground swimming pool without deck. Required clearance is maintained aboveground.

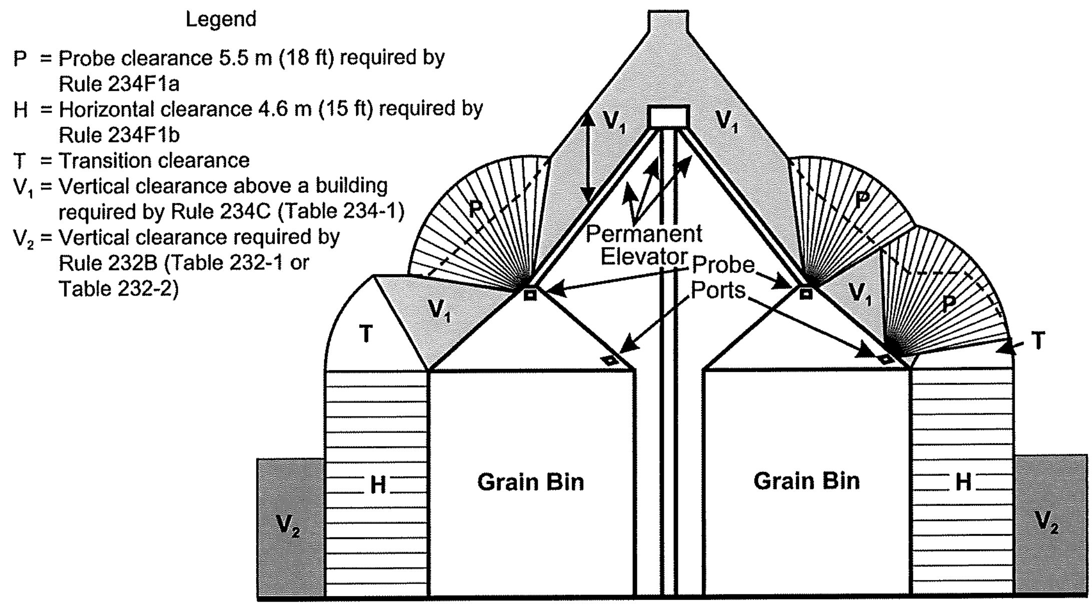


Figure 234-4(a)—Clearance envelope for grain bins filled by permanently installed augers, conveyors, or elevators

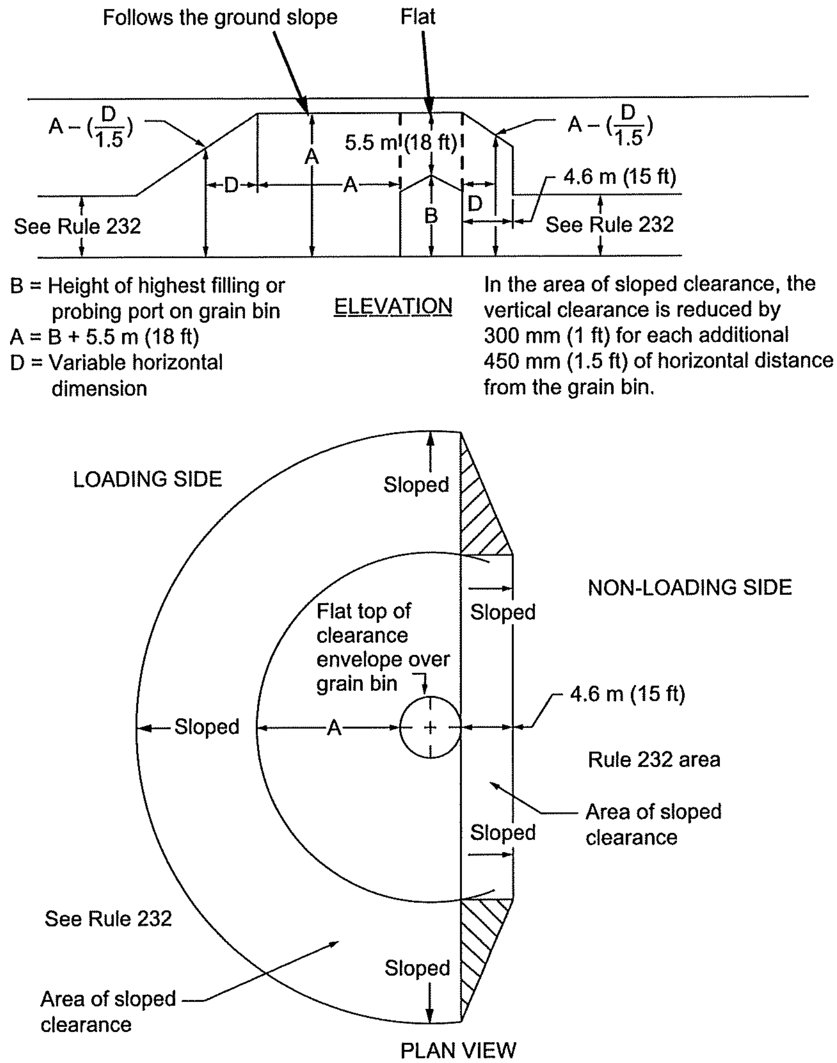


Figure 234-4(b)—Clearance envelope for grain bins filled by portable augers, conveyors, or elevators

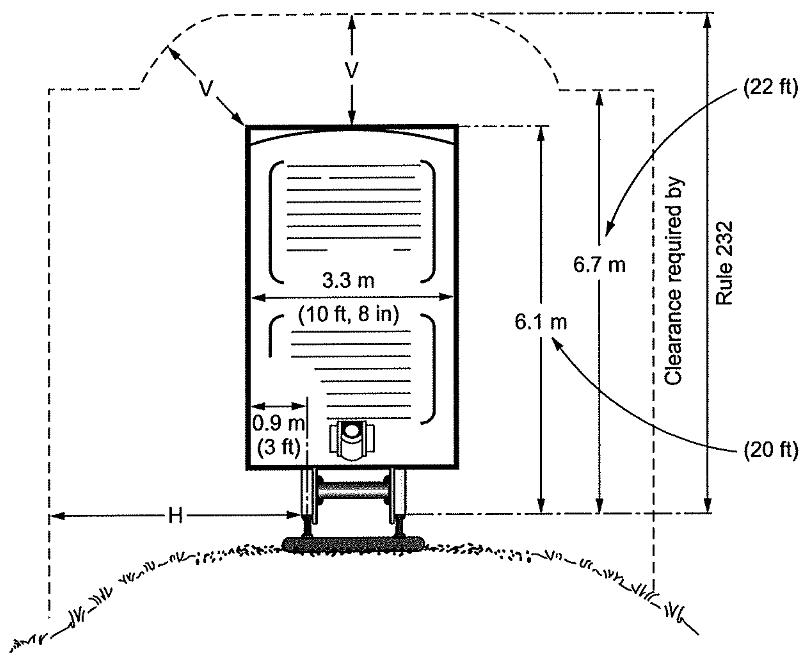


Figure 234-5—Rail car clearances

m

Table 234-1— Clearance of wires, conductors, cables, and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below. See Rules 234A, 234C1a, 234C2, and 234H4.)

Clearance of	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V [11] [16] neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V [5] [16] (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V [15] (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV [5] [14] (m)	Open supply conductors, over 750 V to 22 kV (m)
1. Buildings						
a. Horizontal						
(1) To walls, projections, and guarded windows	1.40 [2] [7]	1.50 [2]	1.50 [2]	1.70 [2] [9]	2.00 [2]	2.30 [2] [10]
(2) To unguarded windows [8]	1.40	1.50	1.50	1.70 [9]	2.00	2.30 [10]
(3) To balconies and areas readily accessible to pedestrians [3]	1.40	1.50	1.50	1.70 [9]	2.00	2.30 [10]
b. Vertical [14]						
(1) Over or under roofs or projections not readily accessible to pedestrians [3]	0.90	1.07	3.0	3.2	3.6	3.8

m

Table 234-1— *(continued)*
Clearance of wires, conductors, cables, and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below.
See Rules 234A, 234C1a, 234C2, and 234H4.)

Clearance of	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V [11] [16] neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V [5] [16] (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V [15] (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV [5] [14] (m)	Open supply conductors, over 750 V to 22 kV (m)
(2) Over or under roofs, balconies, decks, or similar structures readily accessible to pedestrians [3]	3.2	3.4	3.4	3.5	4.0	4.1
(3) Over roofs, ramps, decks, and loading docks accessible to vehicles but not subject to truck traffic [6]	3.2	3.4	3.4	3.5	4.0	4.1
(4) Over roofs, ramps, decks, and loading docks accessible to truck traffic [6] [18]	4.7	4.9	4.9	5.0	5.5	5.6
2. Signs, chimneys, billboards, radio and television antennas, flagpoles and flags, banners, tanks, and other installations not classified as buildings or bridges [17]						

m

Table 234-1— *(continued)*
Clearance of wires, conductors, cables, and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below.
See Rules 234A, 234C1a, 234C2, and 234H4.)

Clearance of	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ⑪ ⑯ neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V ⑤ ⑯ (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ⑮ (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV ⑤ ⑭ (m)	Open supply conductors, over 750 V to 22 kV (m)
a. Horizontal ④						
(1) To portions that are readily accessible to pedestrians ③	1.40	1.50	1.50	1.70 ⑨	2.00	2.30 ⑩
(2) To portions that are not readily accessible to pedestrians ③	0.90	1.07	1.50 ②	1.70 ②⑨	2.00 ②	2.30② ⑩
b. Vertical						
(1) Over or under catwalks and other surfaces upon which personnel walk	3.2	3.4	3.4	3.5	4.0	4.1
(2) Over or under other portions of such installations ④	0.90	1.07	1.70	1.80	2.30	2.45

NOTE: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2b of Appendix A.

①Not used in this edition.
②Where available space will not permit this value, the clearance may be reduced by 0.60 m wires, provided the wires, conductors, or cables, including splices and taps, and unguarded rigid live parts have a covering that provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact with a structure or building.

③A roof, balcony, or similar structure is considered readily accessible to pedestrians if it can be casually accessed through a doorway, window, ramp, stairway, or permanently mounted ladder by a person, on foot, who neither exerts extraordinary physical effort nor employs tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its bottom rung is 2.45 m or more from the ground or other permanently installed accessible surface or is otherwise equipped with barriers to inhibit climbing by unauthorized persons.

④The required clearances shall be to the closest approach of motorized signs or moving portions of installations covered by Rule 234C.

⑤The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

⑥For the purpose of this rule, trucks are defined as any vehicle exceeding 2.45 m in height.

⑦This clearance may be reduced to 75 mm for the effectively grounded portions of guys.

⑧Windows not designed to open may have the clearances permitted for walls and projections.

⑨The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.07 m; see Rule 234C1b.

⑩The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.40 m; see Rule 234C1b.

⑪The portion of anchor guys below the lowest insulator meeting Rules 279A1 and 215C2a may have the same clearance as effectively grounded guys.

⑫This footnote not used in this edition.

⑬This footnote not used in this edition.

⑭For clearances above railings, walls, or parapets around balconies, decks, or roofs, use the clearances required for row 1b(1). For such clearances where an outside stairway exists to provide access to such balconies, decks, or roofs, use the clearances required for row 2b(2).

⑮Does not include neutral conductors meeting Rule 230E1.

⑯These clearance values also apply to guy insulators.

⑰It is presumed that a flag or banner is fully extended but that there is no deflection or displacement of the flagpole or other supporting structure due to wind and that the conductors, cables, or rigid live parts are not displaced by the wind. The specified clearance is measured to the point of maximum displacement of the banner or flag towards the overhead utility facility.

⑱When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 4.3 m.

ft

Table 234-1—
Clearance of wires, conductors, cables, and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below.
See Rules 234A, 234C1a, 234C2, and 234H4.)

Clearance of	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V [11] [16] neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (ft)	Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (ft)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V [5] [14] (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V [15] (ft)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV [5] [16] (ft)	Open supply conductors, over 750 V to 22 kV (ft)
1. Buildings						
a. Horizontal						
(1) To walls, projections, and guarded windows	4.5 [2][7]	5.0[2]	5.0[2]	5.5[2][9]	7.0[2]	7.5[2][10]
(2) To unguarded windows [8]	4.5	5.0	5.0	5.5[9]	7.0	7.5[10]
(3) To balconies and areas readily accessible to pedestrians [3]	4.5	5.0	5.0	5.5[9]	7.0	7.5[10]
b. Vertical [14]						
(1) Over or under roofs or projections not readily accessible to pedestrians [3]	3.0	3.5	10.0	10.5	12.0	12.5
(2) Over or under roofs, balconies, decks, or similar structures readily accessible to pedestrians [3]	10.5	11.0	11.0	11.5	13.0	13.5

ft

Table 234-1— *(continued)*
Clearance of wires, conductors, cables, and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below. See Rules 234A, 234C1a, 234C2, and 234H4.)

Clearance of	Insulated communication conductors and cables; messengers; overhead shield/surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V [11] [16] neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (ft)	Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (ft)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V [5] [14] (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V [15] (ft)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV [5] [16] (ft)	Open supply conductors, over 750 V to 22 kV (ft)
(3) Over roofs, ramps, decks, and loading docks accessible to vehicles but not subject to truck traffic [6]	10.5	11.0	11.0	11.5	13.0	13.5
(4) Over roofs, ramps, decks, and loading docks accessible to truck traffic [6] [18]	15.5	16.0	16.0	16.5	18.0	18.5
2. Signs, chimneys, billboards, radio and television antennas, flagpoles and flags, banners, tanks, and other installations not classified as buildings or bridges [17]						
a. Horizontal [4]						
(1) To portions that are readily accessible to pedestrians [3]	4.5	5.0	5.0 [2]	5.5 [9]	7.0 [2]	7.5 [10]
(2) To portions that are not readily accessible to pedestrians [3]	3.0	3.5	5.0 [2]	5.5 [2] [9]	7.0 [2]	7.5 [2] [10]

ft

Table 234-1— *(continued)*
Clearance of wires, conductors, cables, and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below.
See Rules 234A, 234C1a, 234C2, and 234H4.)

Clearance of	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ⑪ ⑮ neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (ft)	Supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 (ft)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V ⑤ ⑮ (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ⑮ (ft)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV ⑤ ⑮ (ft)	Open supply conductors, over 750 V to 22 kV (ft)
b. Vertical						
(1) Over or under catwalks and other surfaces upon which personnel walk	10.5	11.0	11.0	11.5	13.0	13.5
(2) Over or under other portions of such installations ④	3.0	3.5	5.5	6.0	7.5	8.0

NOTE: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2b of Appendix A.

① Not used in this edition.
②Where available space will not permit this value, the clearance may be reduced by 2 ft provided the wires, conductors, or cables, including splices and taps, and unguarded rigid live parts have a covering that provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact with a structure or building.
③A roof, balcony, or similar structure is considered readily accessible to pedestrians if it can be casually accessed through a doorway, window, ramp, stairway, or permanently mounted ladder by a person, on foot, who neither exerts extraordinary physical effort nor employs tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its bottom rung is 8 ft or more from the ground or other permanently installed accessible surface or is otherwise equipped with barriers to inhibit climbing by unauthorized persons.
④The required clearances shall be to the closest approach of motorized signs or moving portions of installations covered by Rule 234C.
⑤The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
⑥For the purpose of this rule, trucks are defined as any vehicle exceeding 8 ft in height.
⑦This clearance may be reduced to 3 in for the effectively grounded portions of guys.

⑧Windows not designed to open may have the clearances permitted for walls and projections.
⑨The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 3.5 ft; see Rule 234C1b.
⑩The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 4.5 ft; see Rule 234C1b.
⑪The portion of anchor guys below the lowest insulator meeting Rules 279A1 and 215C2a may have the same clearance as effectively grounded guys.
⑫This footnote not used in this edition.
⑬This footnote not used in this edition.
⑭For clearances above railings, walls, or parapets around balconies, decks, or roofs, use the clearances required for row 1b(1). For such clearances where an outside stairway exists to provide access to such balconies, decks, or roofs, use the clearances required for row 2b(2).
⑮Does not include neutral conductors meeting Rule 230E1.
⑯These clearance values also apply to guy insulators.
⑰It is presumed that a flag or banner is fully extended but that there is no deflection or displacement of the flagpole or other supporting structure due to wind and that the conductors, cables, or rigid live parts are not displaced by the wind. The specified clearance is measured to the point of maximum displacement of the banner or flag towards the overhead utility facility.
⑱When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 14 ft.

m

Table 234-2— Clearance of wires, conductors, cables, and unguarded rigid live parts from bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below.
See Rules 234A, 234D1a, and 234H4.)

	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 [7]; ungrounded equipment cases, 0 to 750 V; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors over 300 V to750 V [4] [11] (m)	**Supply cables over 750 V meeting Rule 230C2 or 230C3 [7]; open supply conductors, 0 to 750 V [10] (m)**	**Open supply conduc-tors, over 750 V to 22 kV (m)**	**Unguarded rigid live parts, over 750 V to 22 kV, ungrounded equipment cases, 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 750 V to 22 kV [4] [11] (m)**
1. Clearance over bridges [1]				
a. Attached [3]	0.90	1.07	1.70	1.50
b. Not attached	3.0	3.2	3.8	3.6
2. Clearance beside, under, or within bridge structure [6]				
a. Readily accessible portions of any bridge including wing, walls, and bridge attachments [1]				
(1) Attached [3]	0.90	1.07 [8]	1.70 [9]	1.50
(2) Not attached	1.50	1.70 [8]	2.30 [9]	2.00
b. Ordinarily inaccessible portions of bridges (other than brick, concrete, or masonry) and from abutments [2]				
(1) Attached [3] [5]	0.90	1.07 [8]	1.70 [9]	1.50
(2) Not attached [4] [5]	1.20	1.40 [8]	2.00 [9]	1.80

[1] Where over traveled ways on or near bridges, the clearances of Rule 232 apply also.
[2] Bridge seats of steel bridges carried on masonry, brick, or concrete abutments that require frequent access for inspection shall be considered as readily accessible portions.

③Clearance from supply conductors to supporting arms and brackets attached to bridges shall be the same as specified in Table 235-6 (Rule 235E1) if the supporting arms and brackets are owned, operated, or maintained by the same utility.

④ The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

⑤Where conductors passing under bridges are adequately guarded against contact by unauthorized persons and can be de-energized and grounded per Rule 444D for maintenance of the bridge, clearances of the conductors from the bridge, at any point, may have the clearances specified in Table 235-6 for clearance from surfaces of support arms plus one-half the final sag at 15 °C (60 °F), no wind of the conductor at that point.

⑥Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.

⑦Where permitted by the bridge owner, supply cables may be run in rigid conduit attached directly to the bridge. Refer to Part 3 for installation rules.

⑧The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.07 m; see Rule 234D1b.

⑨The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.40 m; see Rule 234D1b.

⑩Does not include neutral conductors meeting Rule 230E1.

⑪These clearance values also apply to guy insulators.

ft

Table 234-2—
Clearance of wires, conductors, cables, and unguarded rigid live parts from bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below. See Rules 234A, 234D1a, and 234H4.)

	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 ⑦, ungrounded equipment cases, 0 to 750 V; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors over 300 V to750 V ④ ⑪ (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3 ⑦; open supply conductors, 0 to 750 V ⑩ (ft)	Open supply conductors, over 750 V to 22 kV (ft)	Unguarded rigid live parts, over 750 V to 22 kV, ungrounded equipment cases, 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 750 V to 22 kV ④ ⑪ (ft)
1. Clearance over bridges ①				
a. Attached ③	3.0	3.5	5.5	5.0
b. Not attached	10.0	10.5	12.5	12.0
2. Clearance beside, under, or within bridge structure ⑥				

ft

Table 234-2— *(continued)*
Clearance of wires, conductors, cables, and unguarded rigid live parts from bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below.
See Rules 234A, 234D1a, and 234H4.)

	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3 [7], ungrounded equipment cases, 0 to 750 V; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors over 300 V to750 V [4] [11] (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3 [7]; open supply conductors, 0 to 750 V [10] (ft)	Open supply conductors, over 750 V to 22 kV (ft)	Unguarded rigid live parts, over 750 V to 22 kV, ungrounded equipment cases, 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 750 V to 22 kV [4] [11] (ft)
a. Readily accessible portions of any bridge including wing, walls, and bridge attachments [1]				
(1) Attached [3]	3.0	3.5 [8]	5.5 [9]	5.0
(2) Not attached	5.0	5.5 [8]	7.5 [9]	7.0
b. Ordinarily inaccessible portions of bridges (other than brick, concrete, or masonry) and from abutments [2]				
(1) Attached [3] [5]	3.0	3.5 [8]	5.5 [9]	5.0
(2) Not attached [4] [5]	4.0	4.5 [8]	6.5 [9]	6.0

①Where over traveled ways on or near bridges, the clearances of Rule 232 apply also.

②Bridge seats of steel bridges carried on masonry, brick, or concrete abutments that require frequent access for inspection shall be considered as readily accessible portions.

③Clearance from supply conductors to supporting arms and brackets attached to bridges shall be the same as specified in Table 235-6 (Rule 235E1) if the supporting arms and brackets are owned, operated, or maintained by the same utility.

④The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

⑤Where conductors passing under bridges are adequately guarded against contact by unauthorized persons and can be de-energized and grounded per Rule 444D for maintenance of the bridge, clearances of the conductors from the bridge, at any point, may have the clearances specified in Table 235-6 for clearance from surfaces of support arms plus one-half the final sag at 15 °C (60 °F), no wind of the conductor at that point.

⑥Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.

⑦Where permitted by the bridge owner, supply cables may be run in rigid conduit attached directly to the bridge. Refer to Part 3 for installation rules.

⑧The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 3.5 ft; see Rule 234D1b.

⑨The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 4.5 ft; see Rule 234D1b.

⑩Does not include neutral conductors meeting Rule 230E1.

⑪These clearance values also apply to guy insulators.

m

Table 234-3—Clearance of wires, conductors, cables, or unguarded rigid live parts over or near swimming pools

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.
Clearances are with no wind displacement.
See Rules 234A, 234E1, 234E2, and 234H4.)

	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ② ④; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V ① ④ (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ③ (m)	Unguarded rigid live parts over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV ① ④ (m)	Open supply conductor s, over 750 V to 22 kV (m)
A. Clearance in any direction from the water level, edge of pool, base of diving platform, or anchored raft	6.7	6.9	7.0	7.5	7.6
B. Clearance in any direction to the diving platform, tower, water slide, or other fixed, pool-related structures	4.3	4.4	4.6	5.1	5.2

m

Table 234-3—Clearance of wires, conductors, cables, or unguarded rigid live parts over or near swimming pools *(continued)*

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.
Clearances are with no wind displacement.
See Rules 234A, 234E1, 234E2, and 234H4.)

	Insulated communication conductors and cables; messengers; overhead shield/surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ②④; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V ①④ (m)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ③ (m)	Unguarded rigid live parts over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV ①④ (m)	Open supply conductor s, over 750 V to 22 kV (m)
V. Vertical clearance over adjacent land	Clearance shall be as required by Rule 232.				

NOTE 1: A, B, and V are shown in Figure 234-3(a).
NOTE 2: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2b of Appendix A.

①The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
②The portion of anchor guys below the lowest insulator meeting Rules 279A1 and 215C2a may have the same clearance as effectively grounded guys.
③Does not include neutral conductors meeting Rule 230E1.
④These clearance values also apply to guy insulators.

ft

Table 234-3—Clearance of wires, conductors, cables, or unguarded rigid live parts over or near swimming pools

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.
Clearances are with no wind displacement.
See Rules 234A, 234E1, 234E2, and 234H4.)

	Insulated communication conductors and cables; messengers; overhead shield/ surge-protection wires; effectively grounded guys; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to 0 to 300 V ②④; neutral conductors meeting Rule 230E1; supply cables meeting Rule 230C1 (ft)	Unguarded rigid live parts, 0 to 750 V; noninsulated communication conductors; supply cables of 0 to 750 V meeting Rule 230C2 or 230C3; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to open supply conductors of over 300 V to 750 V ①④ (ft)	Supply cables over 750 V meeting Rule 230C2 or 230C3; open supply conductors, 0 to 750 V ③ (ft)	Unguarded rigid live parts over 750 V to 22 kV; ungrounded portions of guys meeting Rules 215C2 and 279A1 exposed to over 750 V to 22 kV ①④ (ft)	Open supply conduct-ors, over 750 V to 22 kV (ft)
A. Clearance in any direction from the water level, edge of pool, base of diving platform, or anchored raft	22.0	22.5	23.0	24.5	25.0
B. Clearance in any direction to the diving platform, tower, water slide, or other fixed, pool-related structures	14.0	14.5	15.0	16.5	17.0
V. Vertical clearance over adjacent land	Clearance shall be as required by Rule 232.				

NOTE 1: A, B, and V are shown in Figure 234-3(a).
NOTE 2: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table A-1 to the applicable Reference Component of Table A-2b of Appendix A.

①The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not effectively grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
②The portion of anchor guys below the lowest insulator meeting Rules 279A1 and 215C2a may have the same clearance as effectively grounded guys.
③Does not include neutral conductors meeting Rule 230E1.
④These clearance values also apply to guy insulators.

Table 234-4—
Electrical component of clearance of buildings, bridges, and other installations
[This clearance shall be increased 3% for each 300 m (1000 ft) in excess of 450 m (1500 ft) above mean sea level. See Rules 234H3a and 234H3b.]

Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Switching surge (kV)	Electrical component of clearances			
			Vertical		Horizontal	
			(m)	(ft)	(m)	(ft)
242	2.0	395	0.84	2.8	0.70	2.3
	2.2	435	0.98	3.3	0.82	2.7
	2.4	474	1.14	3.8	0.95	3.1
	2.6	514	1.30	4.3	1.08	3.6
	2.8	553	1.47	4.8	1.22	4.0
	3.0	593	1.64	5.4	1.37	4.5
362	1.8	532	1.38	4.5	1.15	3.8
	2.0	591	1.64	5.4	1.37	4.5
	2.2	650	1.92	6.3	1.60	5.3
	2.4	709	2.22	7.3	1.85	6.1
	2.6	768	2.53	8.3	2.11	6.9
	2.8	828	2.87	9.4	2.39	7.9
	3.0	887	3.3	10.6	2.68	8.8
550	1.6	719	2.27	7.5	1.86	6.2
	1.8	808	2.76	9.1	2.30	7.6
	2.0	898	3.3	10.8	2.74	9.0
	2.2	988	3.9	12.7	3.3	10.5
	2.4	1079	4.5	14.6	3.8	12.2
	2.6	1168	5.1	16.7	4.3	13.9
800	1.6	1045	4.3	13.9	3.6	11.6
	1.8	1176	5.2	16.9	4.3	14.1
	2.0	1306	6.2	20.1	5.2	16.7
	2.2	1437	7.2	23.6	6.0	19.6
	2.4	1568	8.4	27.2	7.0	22.7

Table 234-5—Reference distances

(See Rule 234H2.)

Reference distance	Vertical (m)	Vertical (ft)	Horizontal (m)	Horizontal (ft)
a. Buildings	2.70	9	0.90	3
b. Signs, chimneys, radio and television antennas, tanks, and other installations not classified as bridges or buildings	2.70	9	0.90	3
c. Superstructure of bridges ① ②	2.70	9	0.90	3
d. Supporting structures of another line	1.80	6	1.50	5
e. Dimension *A* of Figure 234-3(a)	5.5	18	—	—
f. Dimension *B* of Figure 234-3(a)	4.3	14	4.3	14

①Where over traveled ways on or near bridges, the clearances of Rule 232 apply also.
②Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.

m

Table 234-6—Clearance over roof not readily accessible ①

[See Rule 324C3d(1).]

	Cable type	Clearance over portions of roof within 1.8 m radius of the service mast			Clearance over portions of roof outside 1.8 m radius of the service mast		
		Voltage ②			Voltage ②		
		0 to 300 V	301 to 750 V	Over 750 V	0 to 300 V	301 to 750 V	Over 750 V
Mast not more than 1.2 m from nearest roof edge	230C3 230C2	0.457	0.457	NA	0.9	0.9	NA
	230C1	0.457	0.457	0.457	0.9	0.9	0.9
	230D	0.457	3.0	NA	0.9	3.0	NA
Mast more than 1.2 m from nearest roof edge	230C3 230C2	0.9	0.9	NA	0.9	0.9	NA
	230C1	0.9	0.9	0.9	0.9	0.9	0.9
	230D	0.9	3.0	NA	0.9	3.0	NA

① If the roof is readily accessible, a clearance of not less than 3.0 m vertical clearance for all service drop conductors including the drip loop shall be maintained above all portions of the roof.
② All voltages are between the conductors involved.

ft

Table 234-6—Clearance over roof not readily accessible ①
[See Rule 324C3d(1).]

	Cable type	Clearance over portions of roof within 6.0 ft radius of the service mast			Clearance over portions of roof outside 6.0 ft radius of the service mast		
		Voltage ②			Voltage ②		
		0 to 300 V	301 to 750 V	Over 750 V	0 to 300 V	301 to 750 V	Over 750 V
Mast not more than 4.0 ft from nearest roof edge	230C3 230C2	1.5	1.5	NA	3.0	3.0	NA
	230C1	1.5	1.5	1.5	3.0	3.0	3.0
	230D	1.5	10.0	NA	3.0	10.0	NA
Mast more than 4.0 ft from nearest roof edge	230C3 230C2	3.0	3.0	NA	3.0	3.0	NA
	230C1	3.0	3.0	3.0	3.0	3.0	3.0
	230D	3.0	10.0	NA	3.0	10.0	NA

① If the roof is readily accessible, a clearance of not less than 10 ft vertical clearance for all service drop conductors including the drip loop shall be maintained above all portions of the roof.
② All voltages are between the conductors involved.

235. Clearance for wires, conductors, or cables carried on the same supporting structure

A. Application of rule

1. Multiconductor wires or cables

   Cables, and duplex, triple, or paired conductors supported on insulators or messengers meeting Rule 230C or 230D, whether single or grouped, for the purposes of this rule are considered single conductors even though they may contain individual conductors not of the same phase or polarity.

2. Conductors supported by messengers or span wires

   Clearances between individual wires, conductors, or cables supported by the same messenger, or between any group and its supporting messenger, or between a trolley feeder, supply conductor, or communication conductor, and their respective supporting span wires, are not subject to the provisions of this rule.

3. Line conductors of different circuits

   a. Unless otherwise stated, the voltage between line conductors of different circuits shall be the greater of the following:

      (1) The phasor difference between the conductors involved

      NOTE: A phasor relationship of 180° is considered appropriate where the actual phasor relationship is unknown.

      (2) The phase-to-ground voltage of the higher-voltage circuit

   b. When the circuits have the same nominal voltage, either circuit may be considered to be the higher-voltage circuit.

B. Horizontal clearance between line conductors

1. Fixed supports

Line conductors attached to fixed supports shall have horizontal clearances from each other not less than the larger value required by either Rule 235B1a or 235B1b for the situation concerned. Voltage is between the two conductors for which the clearance is being determined except for railway feeders, which are to ground.

EXCEPTION 1: The pin spacing at buckarm construction may be reduced as specified in Rule 236F to provide climbing space.

EXCEPTION 2: Grade N need meet only the requirements of Rule 235B1a.

EXCEPTION 3: These clearances do not apply to cables meeting Rule 230C or covered conductors of the same circuit meeting Rule 230D.

EXCEPTION 4: For voltages to ground exceeding 98 kV ac or 139 kV dc, clearances less than those required by a and b below are permitted for systems with known maximum switching-surge factors. (See Rule 235B3.)

a. Horizontal clearance between line conductors of the same or different circuits

Clearances shall be not less than those given in Table 235-1.

b. Clearance according to sags

The clearance at the supports of line conductors of the same or different circuits of Grade B or C shall be not less than the values given by the following formulas, at a conductor temperature of 15 °C (60 °F), at final sag, no wind. For the purpose of this rule, the line conductor clearances are between the surfaces of the conductors only, not including armor rods, tie wires, or other fasteners. The requirements of Rule 235B1a apply if they give a greater clearance than this rule.

When using the applicable formula with a fixed conductor clearance to determine maximum allowable sag for that conductor clearance, the resultant maximum sag shall be rounded down.

EXCEPTION: No requirement is specified for clearance between conductors of the same circuit when rated above 50 kV.

In the following, S is the final sag in millimeters of the conductor having the greater sag, and the clearance is in millimeters. Voltage (kV) is the voltage between the conductors.

(1) For line conductors smaller than AWG No. 2: clearance = 7.6 mm per kV + $20.4\sqrt{S-610}$. (Table 235-2 shows selected values up to 46 kV.)

(2) For line conductors of AWG No. 2 or larger: clearance = 7.6 mm per kV + $8\sqrt{(2.12S)}$. (Table 235-3 shows selected values up to 46 kV.)

(3) For voltages exceeding 814 kV, the clearance shall be determined by the alternate method given by Rule 235B3.

(4) The clearance for voltages exceeding 50 kV specified in Rules 235B1b(1) and (2) shall be increased 3% for each 300 m in excess of 1000 m above mean sea level. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

In the following, S is the final sag in inches of the conductor having the greater sag, and the clearance is in inches. Voltage (kV) is the voltage between the conductors.

(1) For line conductors smaller than AWG No. 2: clearance = 0.3 in per kV + $4.04\sqrt{S-24}$. (Table 235-2 shows selected values up to 46 kV.)

(2) For line conductors of AWG No. 2 or larger: clearance = 0.3 in per kV + $8\sqrt{S/12}$. (Table 235-3 shows selected values up to 46 kV.)

(3) For voltages exceeding 814 kV, the clearance shall be determined by the alternate method given by Rule 235B3.

(4) The clearance for voltages exceeding 50 kV specified in Rules 235B1b(1) and 235B1b(2) shall be increased 3% for each 1000 ft in excess of 3300 ft above mean sea level. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

2. Suspension insulators

Where suspension insulators are used and are not restrained from movement, the clearance between conductors shall be increased so that one string of insulators may swing transversely throughout a range of insulator swing up to its maximum design swing angle without reducing the values given in Rule 235B1. The maximum design swing angle shall be based on a 290 Pa (6 lb/ft^2) wind on the conductor at final sag at 15 °C (60 °F). This may be reduced to a 190 Pa (4 lb/ft^2) wind in areas sheltered by buildings, terrains, or other obstacles. Trees are not considered to shelter a line. The displacement of the wires, conductors, and cables shall include deflection of flexible structures and fittings, where such deflection would reduce the horizontal clearance between two wires, conductors, or cables.

3. Alternate clearances for different circuits where one or both circuits exceed 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 235B1 and 235B2 may be reduced for circuits with known switching-surge factors but shall be not less than the clearances derived from the following computations. For these computations, communication conductors and cables, guys, messengers, neutral conductors meeting Rule 230E1, and supply cables meeting Rule 230C1 shall be considered line conductors at zero voltage.

a. Clearance

(1) The alternate clearance shall be maintained under the expected loading conditions and shall be not less than the electrical clearance between conductors of different circuits computed from the following equation. For convenience, clearances for typical system voltages are shown in Table 235-4.

$$D = 1.00\left[\frac{V_{L-L} \cdot (PU) \cdot a}{500K}\right]^{1.667} b \qquad \text{(m)}$$

$$D = 3.28\left[\frac{V_{L-L} \cdot (PU) \cdot a}{500K}\right]^{1.667} b \qquad \text{(ft)}$$

where

V_{L-L} = maximum ac crest operating voltage in kilovolts between phases of different circuits or maximum dc operating voltage between poles of different circuits. If the phases are of the same phase and voltage magnitude, one phase conductor shall be considered grounded

PU = maximum switching-surge factor expressed in per-unit peak operating voltage between phases of different circuits and defined as a switching-surge level between phases for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

K = 1.4, the configuration factor for a conductor-to-conductor gap

(2) The value of D shall be increased 3% for each 300 m (1000 ft) in excess of 450 m (1500 ft) above mean sea level.

b. Limit

The clearance derived from Rule 235B3a shall not be less than the basic clearances given in Table 235-1 computed for 169 kV ac.

C. Vertical clearance at the support for line conductors and service drops

All line wires, conductors, cables, and service drops located at different levels on the same supporting structure shall have vertical clearances not less than the following:

1. Basic clearance for line wires, conductors, ~~and~~ cables, and service drops of same or different circuits

a. Between supply lines of the same or different circuits

The clearance requirements given in Table 235-5 shall apply to supply wires, conductors, or cables of 0 to 50 kV attached to supports. No value is specified for clearances between conductors of the same circuit exceeding 50 kV or between ungrounded open supply conductors 0 to 50 kV of the same phase and circuit of the same utility.

b. Between supply lines and communication lines

The clearance requirements given in Table 235-5 shall apply.

c. Between communication lines located in the communication space

The clearance and spacing requirements of Rule 235H shall apply to communication lines located in the communication space.

d. Between communication lines located in the supply space

The clearance requirements of Table 235-5 shall apply to communication lines located in the supply space.

EXCEPTION 1: Line wires, conductors, or cables on vertical racks or separate brackets placed vertically and meeting the requirements of Rule 235G may have spacings as specified in that rule.

EXCEPTION 2: Where communication service drops cross under supply conductors on a common crossing structure, the clearance between the communication conductor and an effectively grounded supply conductor may be reduced to 100 mm (4 in) provided the clearance between the communication conductor and supply conductors not effectively grounded meets the requirements of Rule 235C as appropriate.

EXCEPTION 3: Supply service drops of 0 to 750 V running above and parallel to communication service drops may have a clearance of not less than 300 mm (12 in) at any point in the span including the point of their attachment to the building or structure being served provided that the nongrounded conductors are insulated and that the clearance as otherwise required by this rule is maintained between the two service drops at the pole.

EXCEPTION 4: This rule does not apply to conductors of the same circuit meeting Rule 230D.

2. Additional clearances

Greater clearances than those required (by Rule 235C1) and given in Table 235-5 shall be provided under the following conditions. The increases are cumulative where more than one is applicable.

a. Voltage related clearances

(1) For voltages between 50 and 814 kV, the clearance between line wires, conductors, or cables of different circuits shall be increased 10 mm (0.4 in) per kilovolt in excess of 50 kV.

EXCEPTION: For voltages to ground exceeding 98 kV ac or 139 kV dc, clearances less than those required above are permitted for systems with known switching-surge factors. (See Rule 235C3.)

EXAMPLES: Calculations of clearances required by Rule 235C2a for a 69.7 kV maximum operating voltage phase-to-ground conductor above a 7.2 kV phase-to-ground conductor, assuming conductors are 180° out of phase.

Rule 235C2a: Clearance required at support

(a) Same utility [basic clearance = 0.41 m (16 in)]:

SI units: {0.41 + [(50 – 8.7) × 0.01]} + [(69.7 + 7.2 – 50) × 0.01] = 1.09 m. No rounding required in this example.

Customary units: {16.0 + [(50 – 8.7) × 0.4]} + [(69.7 + 7.2 – 50) × 0.4] = 43.3 in. Round up to 44 in.

(b) Different utilities [basic clearance = 1.00 m (40 in)]:

SI units: {1.00 + [(50 – 8.7) × 0.01]} + [(69.7 + 7.2 – 50) × 0.01] = 1.68 m. No rounding required in this example.

Customary units: {40.0 + [(50 – 8.7) × 0.4]} + [(69.7 + 7.2 – 50) × 0.4] = 67.3 in. Round up to 68 in.

(2) The increase in clearance for voltages in excess of 50 kV specified in Rule 235C2a(1) shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level.

(3) All clearances for lines over 50 kV shall be based on the maximum operating voltage.

(4) No value is specified for clearances between conductors of the same circuit.

b. Sag-related clearances

(1) Line wires, conductors, and cables supported at different levels on the same structures shall have vertical clearances at the supporting structures so adjusted that the clearance at any point in the span shall be not less than any of the following:

(a) For voltages less than 50 kV between conductors, 75% of that required at the supports by Table 235-5.

(b) For voltages more than 50 kV between conductors, use the value as calculated by the following appropriate formula:

If the basic value is 0.41 m (16 in): 0.62 m (24.4 in) plus 10 mm (0.4 in) per kV in excess of 50 kV.

If the basic value is 1.0 m (40 in):1.08 m (42.4 in) plus 10 mm (0.4 in) per kV in excess of 50 kV.

The increase in clearance for voltages in excess of 50 kV specified in Rule 235C2b(1)(b) shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level.

All clearances for lines over 50 kV shall be based on the maximum operating voltage.

EXAMPLES: Calculations of clearances required by Rule 235C2b(1)(b) for a 69.7 kV maximum operating voltage phase-to-ground conductor above a 7.2 kV phase-to-ground conductor, assuming conductors are 180 degrees out of phase.

Rule 235C2b(1)(b): Clearance required at any point in the span

(i) Same utility [basic clearance = 0.41m (16 in)]:

SI units: {0.41 + [(50 – 8.7) × 0.01]} × 0.75 + [(69.7 + 7.2 – 50) × 0.01] = 0.89 m. No rounding required in this example.

Customary units: {16.0 + [(50 – 8.7) × 0.4]} × 0.75 + [(69.7 + 7.2 – 50) × 0.4] = 35.2 in. Round up to 36 in.

(ii) Different utilities [basic clearance = 1.00 m (40 in)]:

SI units: {1.00 + [(50 – 8.7) × 0.01]} × 0.75 + [(69.7 + 7.2 – 50) × 0.01] = 1.33 m. No rounding required in this example.

Customary units: {40.0 + [(50 – 8.7) × 0.4]} × 0.75 + [(69.7 + 7.2 – 50) × 0.4] = 53.2 in. Round up to 54 in.

EXCEPTION 1: For Rules 235C2b(1)(a) and 235C2b(1)(b), the following conductors/ cables may have a clearance of not less than 300 mm (12 in) at any point in the span from communication cables located in the communication space provided (a) the supply neutral meeting Rule 230E1 or messenger is bonded to the communication messenger at intervals specified in Rule 092C1, and (b) a clearance of not less than 0.75 m (30 in) is maintained at the supporting structures between the supply conductors and cables located in the supply space and communication cables located in the communication space:

(1) Neutral conductors meeting Rule 230E1,

(2) Fiber-optic supply cables meeting Rule 230F1a or 230F1b,

(3) Insulated communication cables located in the supply space and supported by an effectively grounded messenger, and

(4) Supply cables meeting Rule 230C1 (including their support brackets) in the supply space running above and parallel to communication cables in the communications space.

Bonding is not required for entirely dielectric cables meeting Rule 230F1b.

EXCEPTION 2: For Rules 235C2b(1)(a) and 235C2b(1)(b), when all parties involved are in agreement, for supply conductors of different utilities, vertical clearance at any point in the span need not exceed 75% of the values required at the support for the same utility by Table 235-5.

(c) For purposes of this determination the vertical clearances required in Rules 235C2b(1)(a) and 235C2b(1)(b) apply to the following conductor temperature and loading conditions specified below in i or ii, whichever produces the greater vertical clearance at the structure.

i. The upper conductor is at final sag at 50 °C (120 °F) or the maximum operating temperature for which the line is designed to operate. The lower conductor is at final sag without electrical loading at the same ambient conditions that are used to determine the operating temperature of the upper conductor

EXCEPTION: Rule 235C2b(1)(c)i does not apply to conductors of the same utility when the upper and lower conductors are of the same circuit, the same size and type, installed at the same sag and tension, and will be without electrical loading simultaneously.

ii. The upper conductor is at final sag at 0 °C (32 °F) with the radial thickness of ice, if any, specified in Table 230-1 for the zone concerned. The lower conductor is at final sag without electrical loading and without ice loading at the same ambient conditions as the upper conductor.

EXCEPTION: Rule 235C2b(1)(c)ii does not apply where experience in an area has shown that different ice conditions do not occur between the upper and lower conductors.

NOTE: The ambient temperature may be less than the 0 °C (32 °F) used for the upper conductor due to the electrical loading that produced the 0 °C (32 °F) used for the upper conductor temperature.

If both *EXCEPTIONS* in Rule 235C2b(1)(c) can be used, then Rule 235C2b does not apply. See Rule 012C.

(2) Sags should be readjusted when necessary to accomplish the foregoing, but not reduced sufficiently to conflict with the requirements of Rule 261H1. In cases where conductors of different sizes are strung to the same sag for the sake of appearance or to maintain unreduced clearance throughout storms, the chosen sag should be such as will keep the smallest conductor involved in compliance with the sag requirements of Rule 261H1.

(3) For span lengths in excess of 45 m (150 ft), vertical clearance at the structure between open supply conductors and communication cables or conductors shall be adjusted so that under conditions of conductor temperature of 15 °C (60 °F), no wind displacement and final sag, no open supply conductor of over 750 V but less than 50 kV shall be lower in the span than a straight line joining the points of support of the highest communication cable or conductor.

EXCEPTION: Effectively grounded supply conductors associated with systems of 50 kV or less need meet only the provisions of Rule 235C2b(1).

3. Alternate clearances for different circuits where one or both exceed 98 kV ac, or 139 kV dc to ground

The clearances specified in Rules 235C1 and 235C2 may be reduced for circuits with known switching-surge factors, but shall not be less than the crossing clearances required by Rule 233C3.

4. Communication worker safety zone

The clearances specified in Rules 235C and 238 create a *communication worker safety zone* between the facilities located in the supply space and facilities located in the communication space, both at the structure and in the span between structures. Except as allowed by Rules 238C, 238D, and 239, no supply or communication facility shall be located in the communication worker safety zone.

D. Diagonal clearance between line wires, conductors, and cables located at different levels on the same supporting structure

No wire, conductor, or cable may be closer to any other wire, conductor, or cable than defined by the dashed line in Table 235-1, where V and H are determined in accordance with other parts of Rule 235.

E. Clearances in any direction at or near a support from line conductors to supports, and to vertical or lateral conductors, service drops, and span or guy wires, attached to the same support

1. Fixed supports

Clearances shall be not less than those given in Table 235-6.

EXCEPTION: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required by Table 235-6 are permitted for systems with known switching-surge factor. (See Rule 235E3.)

NOTE 1: For clearances in any direction from supply line conductors to communication antennas in the supply space attached to the same supporting structure, see Rule 235I.

NOTE 2: For antennas in the communication space, see Rule 236D1 and Rule 238.

2. Suspension insulators

Where suspension insulators are used and are not restrained from movement, the clearance shall be increased so that the string of insulators may swing transversely throughout a range of insulator swing up to its maximum design swing angle without reducing the values given in Rule 235E1. The maximum design swing angle shall be based on a 290 Pa (6 lb/ft^2) wind on the conductor at final sag at 15 °C (60 °F). This may be reduced to a 190 Pa (4 lb/ft^2) wind in areas sheltered by buildings, terrain, or other obstacles. Trees are not considered to shelter a line. The displacement of the wires, conductors, and cables shall include deflection of flexible structures and fittings, where such deflection would reduce the clearance.

3. Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 235E1 and 235E2 may be reduced for circuits with known switching-surge factors but shall not be less than the following:

a. Alternate clearances to anchor guys, surge-protection wires, and vertical or lateral conductors

The alternate clearances shall be not less than the crossing clearances required by Rule 233B3 and Rules 233C3a and 233C3b for the conductor voltages concerned. For the purpose of this rule, anchor guys and surge-protection wires shall be assumed to be at ground potential. The limits of Rule 235E3b(2) shall apply to the clearance derived from Rules 233C3a and 233C3b.

b. Alternate clearance to surface of support arms and structures

(1) Alternate clearance

(a) Basic computation

The alternate clearances shall be maintained under the expected loading conditions and shall be not less than the electrical clearances computed from the following equation. For convenience, clearances for typical system voltages are shown in Table 235-7.

$$D = 1.00\left[\frac{V\cdot(PU)\cdot a}{500K}\right]^{1.667} b \qquad \text{(m)}$$

$$D = 39.37\left[\frac{V\cdot(PU)\cdot a}{500K}\right]^{1.667} b \qquad \text{(in)}$$

where

V = maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations with fixed insulator supports

= 1.05, the allowance for one standard deviation with free-swinging insulators

b = 1.03, the allowance for nonstandard atmospheric conditions

K = 1.2, the configuration factor for conductor-to-tower window

(b) Atmospheric correction

The value of D shall be increased 3% for each 300 m (1000 ft) in excess of 450 m (1500 ft) above mean sea level.

(2) Limits

The alternate clearance shall not be less than the clearance of Table 235-6 for 169 kV ac. The alternate clearance shall be checked for adequacy of clearance to workers and increased, if necessary, where work is to be done on the structure while the circuit is energized. (Also see Part 4.)

F. Clearances between circuits located in the supply space on the same support arm

Different circuits may be maintained in the supply space on the same support arm only under one or more of the five following conditions. For purposes of these determinations, a neutral conductor shall be considered as having the same voltage classification as the circuit with which it is associated:

1. If they occupy positions on opposite sides of the structure.

2. If in bridge-arm or sidearm construction, the clearance is not less than the climbing space required for the higher voltage concerned and provided for in Rule 236.

3. If the higher-voltage conductors occupy the outer positions and the lower-voltage conductors occupy the inner positions.
4. If series lighting or similar supply circuits are ordinarily dead during periods of work on or above the support arm concerned.
5. If the two circuits concerned are communication circuits (located in the supply space in accordance with Rule 224A), or one circuit is such a communication circuit and the other is a supply circuit, provided they are installed as specified in Rule 235F1 or 235F2.

G. Conductor spacing: vertical racks or separate brackets

Conductors or cables may be carried on vertical racks or separate brackets other than wood placed vertically on one side of the structure and securely attached thereto with less clearance between the wires, conductors, or cables than specified in Rule 235C if all the following conditions are met:

1. All wires, conductors, and cables are owned and maintained by the same utility, unless by agreement between all parties involved.
2. The voltage shall be not more than 750 V, except supply cables and conductors meeting Rule 230C1 or 230C2, which may carry any voltage.
3. Conductors shall be arranged so that the vertical spacing shall be not less than that specified in Table 235-8 under the conditions specified in Rule 235C2b(1)(c).

EXCEPTION 1: A supporting neutral conductor of a supply cable meeting Rule 230C3 or an effectively grounded messenger of a supply cable meeting Rule 230C1 or 230C2 may attach to the same insulator or bracket as a neutral conductor meeting Rule 230E1, so long as the clearances of Table 235-8 are maintained in mid-span and insulated energized conductors are positioned away from the open supply neutral at the attachment.

EXCEPTION 2: No mid-span clearance is required where supply cables meeting Rule 230C3 or service drops meeting Rule 234C3a are attached to the neutral conductor meeting Rule 230E1 anywhere in the span.

H. Clearance and spacing between communication conductors, cables, and equipment

1. The spacing between messengers supporting communication cables should be not less than 300 mm (12 in) except by agreement between the parties involved including the pole owner(s).
2. The clearances between the conductors, cables, and equipment of one communication utility to those of another, anywhere in the span, shall be not less than 100 mm (4 in), except by agreement between the parties involved including the pole owner(s).

I. Communication antenna clearances in any direction from supply and communication lines attached to the same supporting structure

1. General

These clearances apply to communication antennas operated at a radio frequency of 3 kHz to 300 GHz, including any associated conductive mounting hardware. Communication antennas located in the supply space shall be installed and maintained only by personnel authorized and qualified to work in the supply space in accordance with the applicable work rules. Antennas function as rigid (vertical or lateral) open wire communication conductors for the purpose of determining clearances under this rule. See also Rule 224A.

2. Communication antenna clearances

a. Communication antennas located in the supply space shall have clearances in any direction from supply lines not less than the value given in Table 235-6, row 1c, and a vertical clearance of not less than 1.00 m (40 in) from communication lines in the communication space.

NOTE: Clearances shown in Table 235-6 are not intended to apply to personnel working in the vicinity of communication antennas. See Rule 420Q.

b. Communication antennas located in the communication space shall have clearances in any direction from communication lines in the communication space not less than the value in

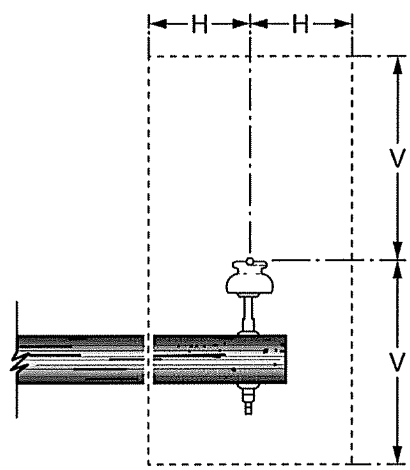
Table 235-6, row 1c, and a vertical clearance from supply conductors located in the supply space not less than the value given in Table 235-5, row 1a.

3. Equipment case that supports or is adjacent to a communication antenna

   The clearance between an equipment case that supports or is adjacent to a communication antenna and a supply line conductor shall be not less than the value given in Table 235-6, row 4a.

4. Vertical or lateral communication conductors and cables attached to a communication antenna

   The clearance between a supply line conductor and the vertical or lateral communication conductor and cable attached to a communication antenna shall be not less than the value given in Rule 239F2.



V = Vertical clearance
H = Horizontal clearance

Figure 235-1—Clearance diagram for energized conductor

Table 235-1—Horizontal clearance between wires, conductors, or cables at supports
(All voltages are between conductors involved except for railway feeders, which are to ground. See also Rules 235A, 235B1a, and 235B3b.)

Class of circuit	Clearance (mm)	Clearance (in)	Notes
Open communication conductors	150	6	Does not apply at conductor transposition points.
	75	3	Permitted where pin spacings less than 150 mm (6 in) have been in regular use. Does not apply at conductor transposition points.
Railway feeders: 0 to 750 V, AWG No. 4/0 or larger 0 to 750 V, smaller than AWG No. 4/0 Over 750 V to 8.7 kV	 150 300 300	 6 12 12	Where 250 mm to 300 mm (10 in to 12 in) clearance has already been established by practice, it may be continued, subject to the provisions of Rule 235B1b, for conductors having final sags not over 900 mm (3 ft) and for voltages not exceeding 8.7 kV.
Supply conductors of the same circuit: 0 to 8.7 kV Over 8.7 kV to 50 kV Above 50 kV	 300 300 plus 10 per kV in excess of 8.7 kV No value specified	 12 12 plus 0.4 per kV in excess of 8.7 kV No value specified	
Supply conductors of different circuits: 0 to 8.7 kV Over 8.7 kV to 50 kV Over 50 kV to 814 kV	 300 300 plus 10 per kV in excess of 8.7 kV 715 plus 10 per kV in excess of 50 kV	 12 12 plus 0.4 per kV in excess of 8.7 kV 29 plus 0.4 per kV in excess of 50 kV	For all voltages above 50 kV, the additional clearance shall be increased 3% for each 300 m (1000 ft) in excess of 1000 m (3300 ft) above mean sea level. All clearances for voltages above 50 kV shall be based on the maximum operating voltage.

m

Table 235-2—Horizontal clearances between line conductors smaller than AWG No. 2 at supports, based on sags

(See also Rules 235A and 235B1b.)

Voltage between conductors (kV)	Sag (mm)							
	915	1220	1830	2440	3050	4570	6095	But not less than ①
	Horizontal clearance (mm)							
2.4	375	525	735	895	1030	1305	1530	300
4.16	390	540	745	905	1040	1320	1545	300
12.47	455	600	810	970	1105	1380	1610	340
13.2	460	605	815	975	1100	1385	1615	345
13.8	465	610	820	980	1115	1390	1620	355
14.4	470	615	825	985	1120	1395	1625	360
24.94	550	695	905	1065	1200	1475	1705	465
34.5	620	770	975	1135	1270	1550	1775	560
46	710	855	1065	1225	1360	1635	1865	675

①Clearance determined by Table 235-1, Rule 235B1a.

NOTE: Clearance = 7.6 per kV + 20.4 $\sqrt{S-610}$, where S is the sag in millimeters.

in

Table 235-2—Horizontal clearances between line conductors smaller than AWG No. 2 at supports, based on sags

(See also Rules 235A and 235B1b.)

Voltage between conductors (kV)	Sag (in)							
	36	48	72	96	120	180	240	But not less than ①
	Horizontal clearance (in)							
2.4	15	21	29	36	41	52	61	12
4.16	16	22	30	36	41	52	61	12
12.47	18	24	32	39	44	55	64	14
13.2	18	24	32	39	44	55	64	14
13.8	19	24	33	39	44	55	64	15
14.4	19	25	33	39	44	55	64	15
24.94	22	28	36	42	48	58	67	19
34.5	25	31	39	45	50	61	70	23
46	28	34	42	49	54	65	74	27

①Clearance determined by Table 235-1, Rule 235B1a.

NOTE: Clearance = 0.3 per kV + 4.04 $\sqrt{S - 24}$, where S is the sag in inches.

m

Table 235-3—Horizontal clearances between line conductors AWG No. 2 or larger at supports, based on sags

(See also Rules 235A and 235B1b.)

Voltage between conductors (kV)	Sag (mm)							
	915	1220	1830	2440	3050	4570	6095	But not less than ①
	Horizontal clearance (mm)							
2.4	375	430	520	595	665	810	930	300
4.16	385	440	530	610	675	820	945	300
12.47	450	505	595	675	740	885	1005	340
13.2	455	510	600	680	745	890	1010	345
13.8	460	515	605	685	750	895	1015	355
14.4	465	520	610	685	755	900	1020	360
24.94	545	600	690	765	835	980	1100	465
34.5	615	670	765	840	910	1050	1175	560
46	705	760	850	925	995	1140	1260	675

① Clearance determined by Table 235-1, Rule 235B1a.

NOTE: Clearance = 7.6 per kV + $8\sqrt{2.12S}$, where S is the sag in millimeters.

in

Table 235-3—Horizontal clearances between line conductors AWG No. 2 or larger at supports, based on sags

(See also Rules 235A and 235B1b.)

Voltage between conductors (kV)	Sag (in)							
	36	48	72	96	120	180	240	But not less than ①
	Horizontal clearance (in)							
2.4	15	17	21	24	27	32	37	12
4.16	16	18	21	24	27	33	38	12
12.47	18	20	24	27	30	35	40	14
13.2	18	20	24	27	30	35	40	14
13.8	18	21	24	27	30	36	40	15
14.4	19	21	24	27	30	36	41	15
24.94	22	24	28	31	33	39	44	19
34.5	25	27	30	33	36	42	47	23
46	28	30	34	37	40	45	50	27

①Clearance determined by Table 235-1, Rule 235B1a.

NOTE: Clearance = 0.3 per kV + 8 $\sqrt{S/12}$, where S is the sag in inches.

Table 235-4—Electrical clearances in Rule 235B3a(1)
[This clearance shall be increased 3% for each 300 m (1000 ft) in excess of 450 m (1500 ft) above mean sea level.]

Maximum operating voltage phase to phase (kV)	Switching surge factor (per unit)	Switching surge (kV)	Electrical component of clearance	
			(m)	(ft)
242	2.6 or less	890 or less	1.94	6.4
	2.8	958	2.20	7.2
	3.0	1027	2.47	8.1
	3.2 or more	1095 or more	2.65 ②	8.8 ②
362	1.8	893 or less	2.06	6.8
	2.0	1024	2.46	8.1
	2.2	1126	2.88	9.5
	2.4	1228	3.4	10.9
	2.6	1330	3.8	12.5
	2.7 or more	1382 or more	3.9 ②	12.8 ②
550	1.6	1245	3.4	11.2
	1.8	1399	4.2	13.6
	2.0	1555	5.0	16.2
	2.2	1711	5.8 ②	19.0 ②
	2.3	1789 or more	5.8 ②	19.1 ②
800	1.6	1810	6.4	20.8
	1.8	2037	7.8	25.3
	1.9 or more	2149 or more	8.3 ②	27.4 ②

①Not used in this edition.
②Need not be greater than specified in Rules 235B1 and 235B2.

m

Table 235-5— Vertical clearance between conductors at supports

(When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. When calculating clearance values within the table, all voltages are between the conductors involved. See the definitions section for voltages of other systems. See also Rules 235A, 235C1, 235C2, and 235F.)

Conductors and cables usually at lower levels [12]	**Conductors and cables usually at upper levels** [12]			
	Supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1; communications cables meeting Rule 224A2 (m)	**Open supply conductors**		
		0 to 8.7 kV [11] **(m)**	**Over 8.7 kV to 50 kV**	
			Same utility [7] **(m)**	**Different utilities** [7] **(m)**
1. Communication conductors and cables				
a. Located in the communication space	1.00 [1] [5]	1.00	1.00	1.00 plus 0.01 per kV [6] in excess of 8.7 kV
b. Located in the supply space	0.41 [9] [10]	0.41 [10]	1.00 [10]	1.00 plus 0.01 per kV [6] in excess of 8.7 kV
2. Supply conductors and cables				
a. Open conductors 0 to 750 V [11]; supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1	0.41 [8] [9]	0.41 [2]	0.41 plus 0.01 per kV [6] in excess of 8.7 kV	1.00 plus 0.01 per kV [6] in excess of 8.7 kV
b. Open conductors over 750 V to 8.7 kV		0.41 [2]	0.41 plus 0.01 per kV [4] [6] in excess of 8.7 kV	1.00 plus 0.01 per kV A [6] in excess of 8.7 kV
c. Open conductors over 8.7 to 22 kV				
(1) If worked on energized with live-line tools and adjacent circuits are neither de-energized nor covered with shields or protectors			0.41 plus 0.01 per kV [6] in excess of 8.7 kV	1.00 plus 0.01 per kV [6] in excess of 8.7 kV

m

Table 235-5— *(continued)*
Vertical clearance between conductors at supports

(When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. When calculating clearance values within the table, all voltages are between the conductors involved. See the definitions section for voltages of other systems. See also Rules 235A, 235C1, 235C2, and 235F.)

Conductors and cables usually at lower levels ⑫	Conductors and cables usually at upper levels ⑫			
	Supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1; communications cables meeting Rule 224A2 (m)	Open supply conductors		
		0 to 8.7 kV ⑪ (m)	Over 8.7 kV to 50 kV	
			Same utility ⑦ (m)	Different utilities ⑦ (m)
(2) If not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live-line tools not requiring line workers to go between live wires			0.41 plus 0.01 per kV ③ ⑥ in excess of 8.7 kV	0.41 plus 0.01 per kV ③ ⑥ in excess of 8.7 kV
d. Open conductors exceeding 22 kV, but not exceeding 50 kV			0.41 plus 0.01 per kV ③ ⑥ in excess of 8.7 kV	1.00 plus 0.01 per kV ③ ⑥ in excess of 8.7 kV

①Where railroad supply circuits of 600 V or less, with transmitted power of 5000 W or less, are run below communication circuits in accordance with Rule 220B2, the clearance may be reduced to 0.41 m.

②Where conductors are operated by different utilities, a vertical clearance of not less than 1.00 m is recommended.

③These values do not apply to conductors of the same circuit or circuits being carried on adjacent conductor supports.

④May be reduced to 0.41 m where conductors are not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live-line tools not requiring line workers to go between live wires.

⑤May be reduced to 0.75 m for supply neutrals meeting Rule 230E1, fiber-optic supply cables on an effectively grounded messenger meeting Rule 230F1a, entirely dielectric fiber-optic supply cables meeting Rule 230F1b, insulated communication cables located in the supply space and supported by an effectively grounded messenger, and cables meeting Rule 230C1 where the supply neutral or messenger is bonded to the communication messenger at intervals specified in Rule 092C. Bonding is not required for entirely dielectric cables meeting Rule 230F1b.

⑥The greater of phasor difference or phase-to-ground voltage; see Rule 235A3.

⑦See examples of calculations in Rules 235C2a and 235C2b.

⑧For supply cables meeting Rule 230C3 and neutral conductors meeting Rule 230E1, see Rule 235G.

⑨No clearance is specified between neutral conductors meeting Rule 230E1 and insulated communication cables located in the supply space and supported by an effectively grounded messenger. The cable messenger may be attached to the neutral at the pole or in the span, provided that the cable is positioned away from the neutral to prevent abrasion damage. If the cable messenger is not attached to the neutral in the span, midspan spacing shall be not less than that specified in Rule 235G.

⑩No clearance is specified between fiber-optic supply cables (FOSC) meeting Rule 230F1b and supply cables and conductors. The FOSC may be attached to a supply conductor or cable at the pole or in the span, provided that the FOSC is positioned away from the supply conductor or cable to prevent abrasion damage. If the FOSC is not attached to the neutral in the span, midspan spacing shall be not less than that specified in Rule 235G.

⑪Does not include neutral conductors meeting Rule 230E1.
⑫For simplicity, this table shows clearance requirements between specified facilities located in frequently used positions over or under one another. Where such facilities are located in opposite relative positions from those shown in the table, the table values for usual positions are to be used.

in

Table 235-5—
Vertical clearance between conductors at supports

(When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. When calculating clearance values within the table, all voltages are between the conductors involved. See the definitions section for voltages of other systems. See also Rules 235A, 235C1, 235C2, and 235F.)

Conductors and cables usually at lower levels ⑫	Conductors and cables usually at upper levels ⑫			
	Supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1; communications cables meeting Rule 224A2 (in)	Open supply conductors		
		0 to 8.7 kV ⑪ (in)	Over 8.7 kV to 50 kV: Same utility ⑦ (in)	Over 8.7 kV to 50 kV: Different utilities ⑦ (in)
1. Communication conductors and cables				
a. Located in the communication space	40 ① ⑤	40	40	40 plus 0.4 per kV ⑥ in excess of 8.7 kV
b. Located in the supply space	16 ⑨ ⑩	16 ⑩	40 ⑩	40 plus 0.4 per kV ⑥ in excess of 8.7 kV
2. Supply conductors and cables				
a. Open conductors 0 to 750 V ⑪; supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1	16 ⑧ ⑨	16 ②	16 plus 0.4 per kV ⑥ in excess of 8.7 kV	40 plus 0.4 per kV ⑥ in excess of 8.7 kV
b. Open conductors over 750 V to 8.7 kV		16 ②	16 plus 0.4 per kV ④ ⑥ in excess of 8.7 kV	40 plus 0.4 per kV ⑥ in excess of 8.7 kV
c. Open conductors over 8.7 kV to 22 kV				
(1) If worked on energized with live-line tools and adjacent circuits are neither de-energized nor covered with shields or protectors			16 plus 0.4 per kV ⑥ in excess of 8.7 kV	40 plus 0.4 per kV ⑥ in excess of 8.7 kV

in

Table 235-5— *(continued)*
Vertical clearance between conductors at supports

(When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. When calculating clearance values within the table, all voltages are between the conductors involved. See the definitions section for voltages of other systems. See also Rules 235A, 235C1, 235C2, and 235F.)

Conductors and cables usually at lower levels⑫	Conductors and cables usually at upper levels ⑫			
	Supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1; communications cables meeting Rule 224A2 (in)	Open supply conductors		
		0 to 8.7 kV ⑪ (in)	Over 8.7 kV to 50 kV	
			Same utility ⑦ (in)	Different utilities ⑦ (in)
(2) If not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live-line tools not requiring line workers to go between live wires			16 plus 0.4 per kV ③⑥ in excess of 8.7 kV	16 plus 0.4 per kV ③⑥ in excess of 8.7 kV
d. Open conductors exceeding 22 kV, but not exceeding 50 kV			16 plus 0.4 per kV ③⑥ in excess of 8.7 kV	40 plus 0.4 per kV ③⑥ in excess of 8.7 kV

①Where railroad supply circuits of 600 V or less, with transmitted power of 5000 W or less, are run below communication circuits in accordance with Rule 220B2, the clearance may be reduced to 16 in.

②Where conductors are operated by different utilities, a vertical clearance of not less than 40 in is recommended.

③These values do not apply to conductors of the same circuit or circuits being carried on adjacent conductor supports.

④May be reduced to 16 in where conductors are not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live line tools not requiring line workers to go between live wires.

⑤May be reduced to 30 in for supply neutrals meeting Rule 230E1, fiber-optic supply cables on an effectively grounded messenger meeting Rule 230F1a, entirely dielectric fiber-optic supply cables meeting Rule 230F1b, insulated communication cables located in the supply space and supported by an effectively grounded messenger, and cables meeting meeting Rule 230C1 where the supply neutral or messenger is bonded to the communication messenger at intervals specified in Rule 092C. Bonding is not required for entirely dielectric cables meeting Rule 230F1b.

⑥The greater of phasor difference or phase-to-ground voltage; see Rule 235A3.

⑦See examples of calculations in Rules 235C2a and 235C2b.

⑧For supply cables meeting Rule 230C3 and neutral conductors meeting Rule 230E1, see Rule 235G.

⑨No clearance is specified between neutral conductors meeting Rule 230E1 and insulated communication cables located in the supply space and supported by an effectively grounded messenger. The cable messenger may be attached to the neutral at the pole or in the span, provided that the cable is positioned away from the neutral to prevent abrasion damage. If the cable messenger is not attached to the neutral in the span, midspan spacing shall be not less than that specified in Rule 235G.

⑩No clearance is specified between fiber-optic supply cables (FOSC) meeting Rule 230F1b and supply cables and conductors. The FOSC may be attached to a supply conductor or cable at the pole or in the span, provided that the FOSC is positioned away from the supply conductor or cable to prevent abrasion damage. If the FOSC is not attached to the neutral in the span, midspan spacing shall be not less than that specified in Rule 235G.

[11]Does not include neutral conductors meeting Rule 230E1.
[12]For simplicity, this table shows clearance requirements between specified facilities located in frequently used positions over or under one another. Where such facilities are located in opposite relative positions from those shown in the table, the table values for usual positions are to be used.

mm

Table 235-6— Clearance in any direction from line conductors at or near a support to supports, and to vertical or lateral conductors, service drops, span or guy wires, and to communication antennas attached to the same support

[See also Rules 235A, 235E1, 235E3b(2), and 235I.]

Clearance of line conductors from	Communication lines in general (mm)	Communication lines on jointly used structures (mm)	Supply lines			
			Neutral conductors meeting Rule 230E1 (mm)	Circuit phase-to-phase voltage		
				0 to 8.7 kV [14] (mm)	Over 8.7 kV to 50 kV (mm)	Over 50 kV to 814 kV [4] [9] (mm)
1. Vertical and lateral conductors—at the support[17]						
a. Of the same circuit	75	75	75	75	75 plus 6.5 per kV in excess of 8.7 kV	No value specified
b. Of other circuits [12]	75	75	75	150 [5]	150 plus 10 per kV in excess of 8.7 kV	580 plus 10 per kV in excess of 50 kV
c. Communication [13] antennas	75	75	75	150 [5]	150 plus 10 per kV in excess of 8.7 kV	580 plus 10 per kV in excess of 50 kV
2. Span or guy wires[11]**, or messengers attached to same structure—at or near the support**						
a. When parallel to line	75 [7]	150 [1] [7]	150 [1] [7]	300 [1]	300 plus 10 per kV in excess of 8.7 kV	740 plus 10 per kV in excess of 50 kV
b. Anchor guys	75 [7]	150 [1] [7]	150 [1] [7]	150 [1]	150 plus 6.5 per kV in excess of 8.7 kV	410 plus 6.5 per kV in excess of 50 kV
c. All other	75 [7]	150 [1] [7]	150 [1] [7]	150	150 plus 10 per kV in excess of 8.7 kV	580 plus 10 per kV in excess of 50 kV

mm

Table 235-6— *(continued)*

Clearance in any direction from line conductors at or near a support to supports, and to vertical or lateral conductors, service drops, span or guy wires, and to communication antennas attached to the same support

[See also Rules 235A, 235E1, 235E3b(2), and 235I.]

Clearance of line conductors from	Communication lines in general (mm)	Communication lines on jointly used structures (mm)	Supply lines			
			Neutral conductors meeting Rule 230E1 (mm)	Circuit phase-to-phase voltage		
				0 to 8.7 kV ⑭ (mm)	Over 8.7 kV to 50 kV (mm)	Over 50 kV to 814 kV ④ ⑨ (mm)
3. Surface of support arms—at the support	75 ②	75 ②	75 ⑥	75 ⑧	75 plus 5 per kV in excess of 8.7 kV⑧ ⑩	280 plus 5 per kV in excess of 50 kV
4. Surface of structures—at the support						
a. On jointly used structures	—	125 ②	125 ⑥	125③ ⑧	125 plus 5 per kV in excess of 8.7 kV ⑧ ⑩	330 plus 5 per kV in excess of 50 kV
b. All other	75 ②	—	—	75 ⑧	75 plus 5 per kV in excess of 8.7 kV ⑧ ⑩	280 plus 5 per kV in excess of 50 kV
5. Service drops—in the span: ⑮						
a. Communication	300	300	750 ⑯	750	750 plus 10 per kV in excess of 8.7 kV	1200 plus 10 per kV in excess of 50 kV
b. Supply	N/A	750	300	300	300 plus 10 per kV in excess of 8.7 kV	750 plus 10 per kV in excess of 50 kV

①For guy wires, if practical. For clearances between span wires and communication conductors, see Rule 238C.

On jointly used structures, guys that pass within 300 mm of supply conductors, and also pass within 300 mm of communication cables, shall be protected with a suitable insulating covering where the guy passes the supply conductors, unless the guy is effectively grounded or insulated with a strain insulator at a point below the lowest supply conductor and above the highest communication cable.

The clearance from an insulated or effectively grounded guy to a communication cable may be reduced to 75 mm when abrasion protection is provided on the guy or communication cable.

②Communication conductors may be attached to supports on the sides or bottom of crossarms or surfaces of poles with less clearance.

③This clearance applies only to supply conductors at the support below communication conductors, on jointly used structures.

Where supply conductors are above communication conductors, this clearance may be reduced to 75 mm.

④All clearances for line over 50 kV shall be based on the maximum operating voltage. For voltages exceeding 814 kV, the clearance shall be determined by the alternate method given by Rule 235E3.
⑤For supply circuits of 0 to 750 V, this clearance may be reduced to 75 mm.
⑥A neutral conductor meeting Rule 230E1 may be attached directly to the structure surface.
⑦Guys and messengers may be attached to the same strain plates or to the same through bolts.
⑧For open supply circuits of 0 to 750 V and supply cables of all voltages meeting Rule 230C1, 230C2, or 230C3, this clearance may be reduced to 25 mm. No clearance is specified for phase conductors of such cables where they are physically restrained by a suitable bracket from abrasion against the pole.
⑨The additional clearance for voltages in excess of 50 kV specified in Table 235-6 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
⑩Where the circuit is effectively grounded and the neutral conductor meets Rule 230E1, phase-to-ground voltage may be used to determine the clearance from the surface of support arms and structures.
⑪These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
⑫See Rule 235A3 to determine the voltage between the conductors involved.
⑬These clearances from supply conductors apply to communication antennas located in the supply space and operated at a radio frequency of 3 kHz to 300 GHz. Also see Rules 235I4, 238A, and 239H1, EXCEPTION 3.
⑭Does not include neutral conductors meeting Rule 230E1.
⑮These service drop values apply anywhere in the span but not at the support. For vertical clearances at the support, see Table 235-5.

NOTE: These values were derived from Table 235-5 and Rule 235C2b(1)(a).

⑯This value may be reduced to 300 mm if the supply neutral and communication messenger are electrically bonded together.
⑰For clearance requirements in any direction between vertical or lateral supply conductors located in the supply space and communication line conductors located in the communication space, use the values in Table 235-5, row 1.

in

Table 235-6—
Clearance in any direction from line conductors at or near a support to supports, and to vertical or lateral conductors, service drops, span or guy wires, and to communication antennas attached to the same support

[See also Rules 235A, 235E1, 235E3b(2), and 235I.]

Clearance of line conductors from	Communication lines in general (in)	Communication lines on jointly used structures (in)	Supply lines			
			Neutral conductors meeting Rule 230E1 (in)	Circuit phase-to-phase voltage		
				0 to 8.7 kV [14] (in)	Over 8.7 kV to 50 kV (in)	Over 50 kV to 814 kV [4] [9] (in)
1. Vertical and lateral conductors— at the support[17]						
a. Of the same circuit	3	3	3	3	3 plus 0.25 per kV in excess of 8.7 kV	No value specified
b. Of other circuits [12]	3	3	3	6 [5]	6 plus 0.4 per kV in excess of 8.7 kV	23 plus 0.4 per kV in excess of 50 kV
c. Communication antennas [13]	3	3	3	6 [5]	6 plus 0.4 per kV in excess of 8.7 kV	23 plus 0.4 per kV in excess of 50 kV
2. Span or guy wires[11]**, or messengers attached to same structure—at or near the support**						
a. When parallel to line	3 [7]	6 [1] [7]	6 [1] [7]	12 [1]	12 plus 0.4 per kV in excess of 8.7 kV	29 plus 0.4 per kV in excess of 50 kV
b. Anchor guys	3 [7]	6 [1] [7]	6 [1] [7]	6 [1]	6 plus 0.25 per kV in excess of 8.7 kV	16 plus 0.25 per kV in excess of 50 kV
c. All other	3 [7]	6 [1] [7]	6 [1] [7]	6 [1]	6 plus 0.4 per kV in excess of 8.7 kV	23 plus 0.4 per kV in excess of 50 kV
3. Surface of support arms—at the support	3 [2]	3 [2]	3 [6]	3 [8]	3 plus 0.2 per kV in excess of 8.7 kV [8] [10]	11 plus 0.2 per kV in excess of 50 kV

in

Table 235-6— *(continued)*
Clearance in any direction from line conductors at or near a support to supports, and to vertical or lateral conductors, service drops, span or guy wires, and to communication antennas attached to the same support

[See also Rules 235A, 235E1, 235E3b(2), and 235I.]

Clearance of line conductors from	Communication lines in general (in)	Communication lines on jointly used structures (in)	Supply lines			
			Neutral conductors meeting Rule 230E1 (in)	Circuit phase-to-phase voltage		
				0 to 8.7 kV ⑭ (in)	Over 8.7 kV to 50 kV (in)	Over 50 kV to 814 kV ④ ⑨ (in)
4. Surface of structures— at the support						
a. On jointly used structures	—	5 ②	5 ⑥	5 ③ ⑧	5 plus 0.2 per kV in excess of 8.7 kV ⑧ ⑩	13 plus 0.2 per kV in excess of 50 kV
b. All other	3 ②	—	—	3 ⑧	3 plus 0.2 per kV in excess of 8.7 kV ⑧ ⑩	11 plus 0.2 per kV in excess of 50 kV
5. Service drops— in the span ⑮						
a. Communication	12	12	30⑯	30	30 plus 0.4 per kV in excess of 8.7 kV	47 plus 0.4 per kV in excess of 50 kV
b. Supply	N/A	30	12	12	12 plus 0.4 per kV in excess of 8.7 kV	29 plus 0.4 per kV in excess of 50 kV

①For guy wires, if practical. For clearances between span wires and communication conductors, see Rule 238C.

On jointly used structures, guys that pass within 12 in of supply conductors, and also pass within 12 in of communication cables, shall be protected with a suitable insulating covering where the guy passes the supply conductors, unless the guy is effectively grounded or insulated with a strain insulator at a point below the lowest supply conductor and above the highest communication cable.

The clearance from an insulated or effectively grounded guy to a communication cable may be reduced to 3 in when abrasion protection is provided on the guy or communication cable.

②Communication conductors may be attached to supports on the sides or bottom of crossarms or surfaces of poles with less clearance.

③This clearance applies only to supply conductors at the support below communication conductors, on jointly used structures.

Where supply conductors are above communication conductors, this clearance may be reduced to 3 in.

④All clearances for line over 50 kV shall be based on the maximum operating voltage. For voltages exceeding 814 kV, the clearance shall be determined by the alternate method given by Rule 235E3.

⑤For supply circuits of 0 to 750 V, this clearance may be reduced to 3 in.

⑥A neutral conductor meeting Rule 230E1 may be attached directly to the structure surface.

⑦Guys and messengers may be attached to the same strain plates or to the same through bolts.

⑧For open supply circuits of 0 to 750 V and supply cables of all voltages meeting Rule 230C1, 230C2 or 230C3, this clearance may be reduced to 1 in. No clearance is specified for phase conductors of such cables where they are physically restrained by a suitable bracket from abrasion against the pole.

⑨The additional clearance for voltages in excess of 50 kV specified in Table 235-6 shall be increased 3% for each 1000 ft in excess of 3300 ft above mean sea level.

⑩Where the circuit is effectively grounded and the neutral conductor meets Rule 230E1, phase-to-ground voltage may be used to determine the clearance from the surface of support arms and structures.

⑪These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.

⑫ See Rule 235A3 to determine the voltage between the conductors involved.

⑬These clearances from supply conductors apply to communication antennas located in the supply space and operated at a radio frequency of 3 kHz to 300 GHz. Also see Rules 235I4, 238A, and 239H1, EXCEPTION 3.

⑭Does not include neutral conductors meeting Rule 230E1.

⑮These service drop values apply anywhere in the span but not at the support. For vertical clearances at the support, see Table 235-5.
NOTE: These values were derived from Table 235-5 and Rule 235C2b(1)(a).

⑯This value may be reduced to 12 in if the supply neutral and communication messenger are electrically bonded together.

⑰For clearance requirements in any direction between vertical or lateral supply conductors located in the supply space and communication line conductors located in the communication space, use the values in Table 235-5, row 1.

Table 235-7— Clearance in any direction from line conductors to supports

[See also Rules 235A, 235E3b, and 235E3b(1)(a).]

Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Switching surge (kV)	Computed clearance to supports			
			Fixed		Free swinging at maximum angle	
			(m)	(in)	(m)	(in)
242	2.4	474	0.88 ①	35 ①	0.88 ①	35 ①
	2.6	514	1.01	40	0.88 ①	35 ①
	2.8	553	1.14	45	0.98	39
	3.0	593	1.24 ②	49 ②	1.10	44
	3.2	632	1.24 ②	49 ②	1.22	49
362	1.6	473	0.88 ①	35 ①	0.88 ①	35 ①
	1.8	532	1.07	42	0.92	36
	2.0	591	1.27	50	1.09	43
	2.2	650	1.49	59	1.28	51
	2.4	709	1.72	68	1.48	59
	2.5	739	1.84	73	1.59	63
550	1.6	719	1.76	69	1.51	60
	1.8	808	2.14	84	1.84	73

Table 235-7— *(continued)*
Clearance in any direction from line conductors to supports
[See also Rules 235A, 235E3b, and 235E3b(1)(a).]

Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Switching surge (kV)	Computed clearance to supports			
			Fixed		Free swinging at maximum angle	
			(m)	(in)	(m)	(in)
	2.0	898	2.55	100	2.19	87
	2.2	988	2.78 [2]	111 [2]	2.57	102
800	1.6	1045	3.3	129	2.82	111
	1.8	1176	4.0	157	3.5	136
	1.9	1241	4.1[2]	161 [2]	3.8	148
	2.0	1306	4.1[2]	161 [2]	4.1 [2]	161 [2]

①Shall be not less than that required by Rule 235E3b(2), including the altitude correction for lines as specified in Footnote 9 of Table 235-6.
②Need not be greater than specified in Rules 235E1 and 235E2.

Table 235-8—Vertical spacing between conductors supported on vertical racks or separate brackets

Span length		Vertical spacing between conductors	
(m)	(ft)	(mm)	(in)
0 to 45	0 to 150	100	4
Over 45 to 60	Over 150 to 200	150	6
Over 60 to 75	Over 200 to 250	200	8
Over 75 to 90	Over 250 to 300	300	12

EXCEPTION: The vertical spacing between open wire conductors may be reduced where the conductors are held apart by intermediate spacers, but may not be less than 100 mm (4 in).

236. Climbing space

The following requirements apply only to portions of structures that workers ascend.

A. Location and dimensions

1. A climbing space having the horizontal clearances specified in Rule 236E shall be provided past any conductors, support arms, or other parts.

2. The climbing space need be provided on one side or corner of the support only.

3. The climbing space shall extend vertically past any conductor or other part between levels above and below the conductor as specified in Rules 236E, F, G, and I, but may otherwise be shifted from any side or corner of the support to any other side or corner.

B. Portions of supporting structures in climbing space

Portions of the supporting structure, when included in one side or corner of the climbing space, are not considered to obstruct the climbing space.

C. Support arm location relative to climbing space

Support arms should be located on the same side of the pole.

EXCEPTION: Rule 236C does not apply where double crossarms are used on any pole or where crossarms on any pole are not all parallel.

D. Location of equipment relative to climbing space

1. All supply and communication equipment such as transformers, regulators, capacitors, cable terminals (potheads), amplifiers, loading coils, antennas, photovoltaic panels, power supplies, surge arresters, switches, etc., when located below conductors or other attachments, shall be mounted outside of the climbing space.

2. All exposed ungrounded conductive parts of luminaires and their supports that are not insulated from current-carrying parts shall be maintained at not less than 500 mm (20 in) from the surface of their supporting structure.

   EXCEPTION 1: This may be reduced to 125 mm (5 in) if located on the side of the structure opposite the designated climbing space.

   EXCEPTION 2: This does not apply where the equipment is located at the top or other vertical portion of the structure that is not subject to climbing.

E. Climbing space between conductors

Climbing space between conductors shall be not less than the horizontal clearances specified in Table 235-6. These clearances are intended to provide a clear climbing space of 600 mm (24 in) while the conductors bounding the climbing space are covered with temporarily installed protective covering rated for the voltage involved. The climbing space shall be provided both along and across the line and shall be projected vertically not less than 1.0 m (40 in) above and below the limiting conductors. Where communication conductors are above supply conductors of more than 8.7 kV to ground or 15 kV line to line, the climbing space shall be projected vertically at least 1.50 m (60 in) above the highest supply conductors.

EXCEPTION 1: This rule does not apply if it is the unvarying practice of the employers concerned to prohibit employees from ascending beyond the conductors or equipment of a given line or structure unless the conductors or equipment are de-energized and grounded per Rule 444D.

EXCEPTION 2: For railroad conductors carried on a structure in a position below communications facilities in the manner permitted in Rule 220B2, the climbing space need not extend more than 600 mm (2 ft) above such supply space.

EXCEPTION 3: If the conductors are owned, operated, or maintained by the same utility, the climbing space may be provided by temporarily moving the line conductors using live-line tools.

F. Climbing space on buckarm construction

Method of providing climbing space on buckarm construction

The full width of climbing space shall be maintained on buckarm construction and shall extend vertically in the same position at least 1.0 m (40 in) [or 1.50 m (60 in) where required by Rule 236E] above and below any limiting conductor.

A six-pin crossarm having pin spacing of 370 mm (14.5 in) may be used to provide a 750 mm (30 in) climbing space on one corner of a junction pole by omitting the pole pins on all arms, and inserting pins midway between the remaining pins so as to give a spacing of 185 mm (7.25 in), provided that all of the following conditions are met:

1. Circuits are less than 8.7 kV to ground or 15 kV line to line
2. Span lengths do not exceed 45 m (150 ft)
3. Sags do not exceed 380 mm (15 in) for wires of AWG No. 2 and larger sizes, or 750 mm (30 in) for wires smaller than AWG No. 2
4. Each conductor on the end of every arm is tied to the same side of its insulator
5. The spacing on the next pole is not less than 370 mm (14.5 in)

G. Climbing space past longitudinal runs not on support arms

The full width of climbing space shall be provided past longitudinal runs and shall extend vertically in the same position from 1.0 m (40 in) below the run to a point 1.0 m (40 in) above [or 1.50 m (60 in) where required by Rule 236E]. The width of climbing space shall be measured from the longitudinal run concerned. Longitudinal runs on racks, or cables on messengers, are not considered as obstructing the climbing space if the location, size, and quantity of the cables permit qualified workers to climb past them. This does not apply where communication conductors are above the longitudinal runs concerned.

EXCEPTION 1: If a supply longitudinal run is placed on the side or corner of the supporting structure where climbing space is provided, the width of climbing space shall be measured horizontally from the center of the structure to the nearest supply conductors on support arms, under both of the following conditions:

(a) Where the longitudinal run consists of neutral conductors meeting Rule 230E1, open supply conductors carrying not more than 750 V, or supply cables and conductors meeting Rule 230C, all voltages; and is supported close to the structure as by brackets, racks, or pins close to the structure

(b) Where the nearest supply conductors on support arms are parallel to and on the same side of the structure as the longitudinal run and within 1.20 m (4 ft) above or below the run

EXCEPTION 2: For railroad supply conductors carried on a structure in a position below communications facilities in the manner permitted in Rule 220B2, the climbing space need not extend more than 600 mm (2 ft) above such supply space.

EXCEPTION 3: A service drop less than 750 V and meeting Rule 230C is not considered to obstruct the climbing space if all conductors concerned are covered by rubber protective equipment or otherwise guarded as an unvarying practice before workers climb past them, provided that such a service drop is (1) not closer to the longitudinal run at the point of attachment than the diameter of the pole plus 125 mm (5 in) measured horizontally, and (2) not closer than 950 mm (38 in) measured horizontally to the longitudinal run at a point 750 mm (30 in) on the run measured from the point of attachment at the pole. See Figure 236-1.

H. Climbing space past vertical conductors

Vertical runs physically protected by suitable conduit or other protective covering and securely attached without spacers to the surface of the line structure are not considered to obstruct the climbing space.

I. Climbing space near ridge-pin conductors

The climbing space specified in Table 235-6 shall be provided above the top support arm to the ridge-pin conductor but need not be carried past it.

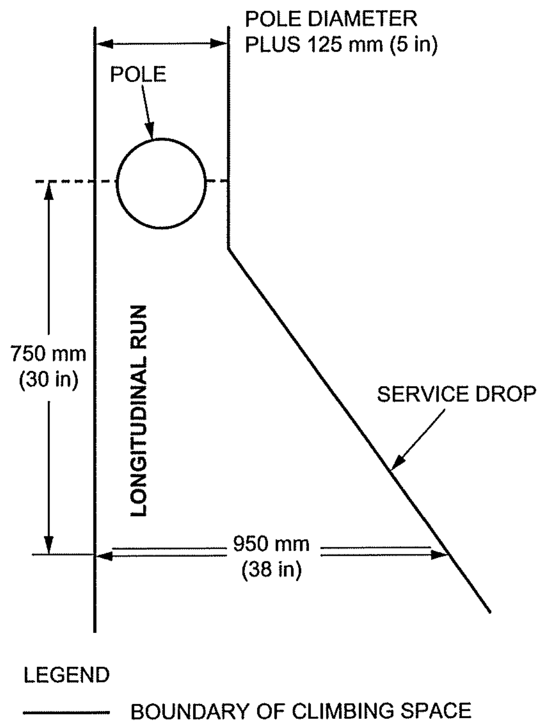


Figure 236-1—Rule 236G, *EXCEPTION 3*

Table 236-1— Horizontal clearance between conductors bounding the climbing space

(All voltages are between the two conductors bounding the climbing space except for communication conductors, which are voltage to ground. Where the two conductors are in different circuits, the voltage between conductors shall be the arithmetic sum of the voltages of each conductor to ground for a grounded circuit, or phase to phase for an ungrounded conductor. See also Rule 236E.)

Character of conductors adjacent to climbing space	Voltage of conductors	Horizontal clearance between conductors bounding the climbing space							
		On structures used solely by				On jointly used structures			
		Communication conductors		Supply conductors		Supply conductors above communication conductors		Communication conductors above supply conductors ①	
		(m)	(in)	(m)	(in)	(m)	(in)	(m)	(in)
1. Communication conductors	0 to 150 V	No requirements			—		②	No requirements	
	Exceeding 150 V	0.60	24 recommended		—		②	0.60	24 recommended
2. Supply cables meeting Rule 230C1	All voltages				—		②		No requirements
3. Supply cables meeting Rule 230C2 or 230C3	All voltages	—	—	0.60	24	0.60	24	0.75	30
4. Open supply line conductors and supply cables meeting Rule 230D	0 to 750 V	—	—	0.60	24	0.60	24	0.75	30
	750 V to 15 kV	—	—	0.75	30	0.75	30	0.75	30
	15 kV to 28 kV	—	—	0.90	36	0.90	36	0.90	36
	28 kV to 38 kV	—	—	1.00	40	1.00	40		
	38 kV to 50 kV	—	—	1.17	46	1.17	46		
	50 kV to 73 kV	—	—	1.40	54	1.40	54		
	Exceeding 73 kV	—	—	>1.40	>54				

NOTE: Attention is called to the operating requirements of Rules 441A and 446C, Part 4, of this Code.

①This relation of levels in general is not desirable and should be avoided.

②Climbing space shall be the same as required for the supply conductors immediately above, with a maximum of 0.75 m (30 in) except that a climbing space of 0.41 m (16 in) across the line may be employed for communication cables or conductors where the only supply conductors at a higher level are secondaries (0 to 750 V) supplying airport or airway marker lights or crossing over the communication line and attached to the pole top or to a pole-top extension fixture.

237. Working space

A. Location of working spaces

Working spaces shall be provided on the climbing face of the structure at each side of the climbing space.

B. Dimensions of working spaces

1. Along the support arm

The working space shall extend from the climbing space to the outmost conductor position on the support arm.

2. At right angles to the support arm

The working space shall have the same dimension as the climbing space (see Rule 236E). This dimension shall be measured horizontally from the face of the support arm.

3. Vertically

The working space shall have a height not less than that required by Rule 235 for the vertical separation of line conductors carried at different levels on the same support.

C. Location of vertical and lateral conductors relative to working spaces

The working spaces shall not be obstructed by vertical or lateral conductors. Such conductors shall be located on the opposite side of the pole from the climbing side or on the climbing side of the pole at a distance from the support arm at least as great as the width of climbing space required for the highest voltage conductors concerned. Vertical conductors enclosed in suitable conduit may be attached on the climbing side of the structure.

D. Location of buckarms relative to working spaces

Buckarms may be used under any of the following conditions, provided the climbing space is maintained. Climbing space may be obtained as in Rule 236F.

1. Standard height of working space

Lateral working space of the height required by Table 235-5 shall be provided between the crossing or tap line conductors attached to the buckarm and the main line conductors. This may be accomplished by increasing the spacing between the line support arms, as shown in Figure 237-1.

2. Reduced height of working space

Where no circuits exceeding 8.7 kV to ground or 15 kV line to line are involved and the clearances of Rules 235B1a and 235B1b are maintained, conductors supported on buckarms may be placed between line conductors having normal vertical spacing, even though such buckarms obstruct the normal working space, provided that a working space of not less than 450 mm (18 in) in height is maintained either above or below line conductors and buckarm conductors.

EXCEPTION: The above working space may be reduced to 300 mm (12 in) if both of the following conditions exist:

(a) Not more than two sets of the line arms and buckarms are involved

(b) Working conditions are rendered safe by providing rubber protective equipment or other suitable devices to insulate and cover line conductors and equipment that are not being worked upon

E. Guarding of energized equipment

Exposed energized parts of equipment such as switches, circuit breakers, surge arresters, etc., shall be enclosed or guarded if all of the following conditions apply:

1. The equipment is located below the top conductor support
2. The equipment is located on the climbing side of the structure
3. The requirements of Rule 441, Part 4, of this Code cannot be met

F. Working clearances from energized equipment

All parts of equipment such as switches, fuses, transformers, surge arresters, luminaires and their support brackets, etc., or other connections that may require operation or adjustment while energized and exposed at such times, shall be so arranged with respect to each other, other equipment, vertical and lateral conductors, and portions of the supporting structure, including supporting platforms or structural members, that in adjustment or operation no portion of the body, including the hands, need be brought closer to any exposed energized parts or conductors than permitted in Part 4, Rule 441 or 446 of this Code.

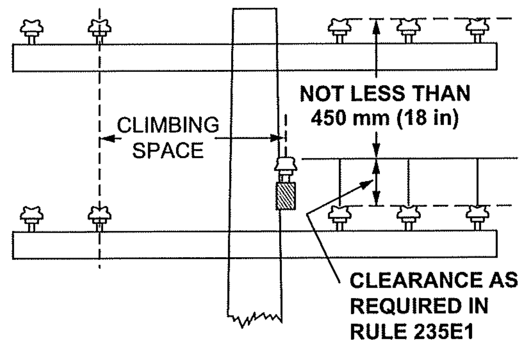


Figure 237-1—Obstruction of working space by buckarm

238. Vertical clearance between specified communications and supply facilities located on the same structure

A. Equipment

For the purpose of measuring clearances under this rule, equipment shall be taken to mean non-current-carrying metal parts of equipment, including metal supports for cables or conductors, metal support braces that are attached to metal supports or are less than 25 mm (1 in) from transformer cases or hangers that are not effectively grounded, and metal or nonmetallic supports or braces associated with communication cables or conductors. Antennas, photovoltaic panels, power supplies, loading coils, etc., shall also be considered equipment for the purpose of measuring clearances under this rule.

B. Clearances in general

Vertical clearances between supply conductors and communications equipment, between communication conductors and supply equipment, and between supply and communications equipment shall be not less than the values specified in Table 238-1, except as provided in Rules 238C and 238D.

C. Clearances for span wires or brackets

Span wires or brackets carrying luminaires, traffic signals, or trolley conductors shall have vertical clearances from communications lines and equipment not less than the values specified in Table 238-2.

D. Clearance of drip loops associated with luminaires and traffic signals

If a drip loop of conductors entering a luminaire, a luminaire bracket, or a traffic signal bracket is above a communication cable, the lowest point of the loop shall be not less than 300 mm (12 in) above the highest (1) communication cable, or (2) through bolt or other equipment.

EXCEPTION: The above clearance may be reduced to 75 mm (3 in) if the loop is covered by a suitable nonmetallic covering that extends at least 50 mm (2 in) beyond the loop.

E. Communication worker safety zone

The clearances specified in Rules 235C and 238 create a communication worker safety zone between the facilities located in the supply space and facilities located in the communication space, both at the structure and in the span between structures. Except as allowed by Rules 238C, 238D, and 239, no supply or communication facility shall be located in the communication worker safety zone.

Table 238-1—Vertical clearance between supply conductors and communications equipment, between communication conductors and supply equipment, and between supply and communications equipment

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See also Rule 238B.)

Supply voltage (kV)	Vertical clearance	
	(m)	(in)
1. Grounded conductor and messenger hardware and supports	0.75	30
2. 0 to 8.7	1.00 ①	40 ①
3. Over 8.7	1.00 plus 0.01 per kV ① in excess of 8.7 kV	40 plus 0.4 per kV ① in excess of 8.7 kV

①Where non-current-carrying parts of supply equipment are effectively grounded and the associated neutral meeting Rule 230E1 or supply cables meeting Rule 230C1 (including the support brackets) are bonded to communication messengers at intervals meeting Rule 092C through out well-defined areas and where communication is at lower levels, clearances may be reduced to 0.75 m (30 in).

Table 238-2—Vertical clearance of span wires and brackets from communication lines and equipment

(See also Rule 238C.)

	Carrying luminaires, traffic signals, or trolley conductors			
	Not effectively grounded		Effectively grounded	
	(mm)	(in)	(mm)	(in)
Above communication support arms	1000	40	500	20 ①
Below communication support arms	1000	40	600	24
Above messengers carrying communication cables	1000	40	100	4
Below messengers carrying communication cables	1000	40	100	4
From terminal box of communication cable	1000	40	100	4
From communication brackets, bridle wire rings, or drive hooks	1000	40	100	4

①This may be reduced to 300 mm (12 in) for either span wires or metal parts of brackets at points 1.0 m (40 in) or more from the structure surface.

239. Clearance of vertical and lateral facilities from other facilities and surfaces on the same supporting structure

Vertical and lateral conductors shall have the clearances required by this rule from other facilities or surfaces on the same supporting structure.

A. General

1. Grounding conductors, surge-protection wires, neutral conductors meeting Rule 230E1, insulated communication conductors and cables, supply cables meeting Rule 230C1 or 350B, insulated supply cables of 0 to 750 V, or conduits may be placed directly on the supporting structure. These conductors, wires, cables, and conduits shall be securely attached to the surface of the structure. Cables not in conduit shall be installed in such a manner as to avoid abrasion at the point of attachment.

2. Installation of supply cable and communication cable in same duct or U-guard type covering

   a. Supply cables 0 to 600 V may be installed together in the same duct or U-guard, if all of the cables are operated and maintained by the same utility.

   b. Supply cables exceeding 600 V meeting Rule 230C1 or 350B may be installed together in the same duct or U-guard if all of the cables are operated and maintained by the same utility.

   c. Supply cables 0 to 600 V and supply cables exceeding 600 V meeting Rule 230C1 or 350B may be installed together in the same duct or U-guard if all of the cables are operated and maintained by the same utility.

   d. Supply cables shall not be installed in the same duct or U-guard with communication cables unless all of the cables are operated and maintained by the same utility.

   e. Communication cables may be installed together in the same duct or U-guard provided all utilities involved are in agreement.

3. Paired communication conductors in rings may be attached directly to a structure or messenger.

4. Insulated supply circuits of 600 V or less and not exceeding 5000 W may be placed in the same cable with control circuits with which they are associated.

5. The term nonmetallic covering as used in Rule 239 refers to material other than a cable jacket that provides an additional barrier against physical contact.

6. Where guarding and protection are required by other rules, either conduit or U-guards may be used.

B. Location of vertical or lateral conductors relative to climbing spaces, working spaces, and pole steps

Vertical or lateral conductors shall be located so that they do not obstruct climbing spaces, or lateral working spaces between line conductors at different levels, or interfere with the safe use of pole steps.

EXCEPTION: This rule does not apply to portions of the structure that workers do not ascend while the conductors in question are energized.

NOTE: See Rule 236H for vertical runs in conduit or other protective covering.

C. Conductors not in conduit

Conductors not encased in conduit shall have the same clearances from conduits as from other surfaces of structures.

D. Guarding and protection near ground

1. Where within 2.45 m (8 ft) of the ground, or other areas readily accessible to the public, all vertical conductors and cables shall be guarded.

   EXCEPTION: This guarding may be omitted from grounding conductors used to ground multi-grounded circuits or equipment (communications or supply); communication cables or conductors; armored cables; or conductors used solely to protect structures from lightning.

2. Where guarding is required by Rule 239D1, either conduit or U-guards may be used. A backing plate shall be used with a U-guard unless the U-guard fits tightly to the supporting structure surface.
3. When guarding is not required, conductors and cables shall be securely attached to the surface of the structure or to standoff brackets and located, where practical, on the portion of the structure having the least exposure to mechanical damage.
4. Guards that completely enclose grounding conductors of lightning-protection equipment shall be of nonmetallic materials or shall be bonded at both ends to the grounding conductor.

E. Requirements for vertical and lateral supply conductors on supply line structures or within supply space on jointly used structures

1. General clearances

In general, clearances shall be not less than the values specified in Table 239-1 or Rule 235E.

2. Special cases

The following requirements apply only to portions of a structure that workers ascend while the conductors in question are energized.

a. General

If open-line conductors are within 1.20 m (4 ft) of the pole, vertical conductors shall be run in one of the following ways:

(1) The clearance between open vertical conductors and pole-surface shall be not less than that given in Table 239-2 within the zone specified in the table.

(2) Within the zone above and below open supply conductors as given in Table 239-2, vertical and lateral conductors or cables attached to the surface of the structure shall be enclosed in nonmetallic conduit or protected by non-metallic covering.

EXCEPTION: This conduit or covering may be omitted from grounding conductors, surge-protection wires, neutral conductors meeting Rule 230E1, supply cables meeting Rule 230C1, and jacketed multiple-conductor supply cables of 0 to 750V, where such conductors or cable are not in the climbing space.

For the purpose of this *EXCEPTION*, a jacketed multiple-conductor cable is a cable with a jacket enclosing the entire cable assembly.

b. Conductors to luminaires

On structures used only for supply lines or on jointly used structures where the luminaire bracket is 1.0 m (40 in) or more above all communication attachments, open wires may be run from the supply line arm directly to the head of a luminaire, provided the clearances of Table 239-1 are obtained and the open wires are securely supported at both ends.

F. Requirements for vertical and lateral communication conductors on communication line structures or within the communication space on jointly used structures

1. Clearances from communication conductors

The clearances of uninsulated vertical and lateral communication conductors from other communication conductors (except those in the same ring run) and from guy, span, or messenger wires shall be not less than those given in Rule 235E1, Table 235-6.

2. Clearances from supply conductors

The vertical clearance of vertical and lateral insulated communication conductors shall be not less than 1.0 m (40 in) from any supply conductors (other than vertical runs or luminaire leads) of 8.7 kV or less, or 1.0 m (40 in) plus 10 mm (0.4 in) per kV in excess of 8.7 to 50 kV. The additional clearance of Rule 235C2 is applicable when the voltage exceeds 50 kV.

EXCEPTION 1: May be reduced to 0.75 m (30 in) from supply neutrals meeting Rule 230E1, cables meeting Rule 230C1, and fiber-optic supply cables where the supply neutral or messenger is bonded to the communication messenger.

EXCEPTION 2: These clearances do not apply where the railroad supply circuits involved are those carried in the manner specified in Rule 220B2.

G. Requirements for vertical supply conductors and cables passing through communication space on jointly used line structures

1. Guarding—General

Vertical supply conductors or cables attached to the structure shall be guarded with suitable conduit or covering from 1.0 m (40 in) above the highest communication attachment to 1.80 m (6 ft) below the lowest communication attachment, except as allowed by Rule 238D.

EXCEPTION 1: This conduit or covering may be omitted from neutral conductors meeting Rule 230E1, supply cables meeting Rule 230C1a, and jacketed multiple-conductor supply cables of 0 to 750 V, where such conductors or cable are not in the climbing space.

For the purpose of this *EXCEPTION*, a jacketed multiple-conductor cable is a cable with a jacket enclosing the entire cable assembly.

EXCEPTION 2: This conduit or covering may be omitted from supply grounding conductors where there are no trolley or ungrounded traffic signal attachments, or ungrounded street lighting fixtures located below the communication attachment, provided:

(a) The grounding conductor is directly (metallically) connected to a conductor which forms part of an effective grounding system,

(b) The grounding conductor has no connection to supply equipment between the grounding electrode and the effectively grounded conductor unless the supply equipment has additional connections to the effectively grounded conductor, and

(c) The grounding conductor is bonded to grounded communication facilities at that structure.

2. Cables and conductors in conduit or covering

Cables and conductors of all voltages may be run in a nonmetallic conduit or covering or in a grounded metallic conduit or covering in accordance with Rule 239A1. Where a metallic conduit or covering is not bonded to grounded communications facilities at that structure, such metal conduit or covering shall have a nonmetallic covering from 1.0 m (40 in) above the highest communication attachment to 1.80 m (6 ft) below the lowest communication attachment.

3. Protection near trolley, ungrounded traffic signal, or ungrounded luminaire attachments

Vertical supply conductors or cables attached to the structure shall be guarded with suitable nonmetallic conduit or covering on structures that carry a trolley or ungrounded traffic signal attachment or an ungrounded luminaire that is attached below the communication cable. The cable shall be protected with nonmetallic covering from 1.0 m (40 in) above the highest communication wire to 1.80 m (6 ft) below the lowest trolley attachment or ungrounded luminaire fixture or ungrounded traffic signal attachment.

4. Service drops

Where supply cables are used as service drops, the point where such cables leave the structure (takeoff point) shall be outside of the communication worker safety zone [not less than 1.0 m (40 in) above the highest or 1.0 m (40 in) below the lowest communication attachment]. See Rules 235C4 and 238E. Within the communication space, all splices and connections in the energized phase conductors shall be insulated.

5. Clearance from through bolts and other metal objects

Vertical runs of supply conductors or cables shall have a clearance of not less than 50 mm (2 in) from exposed through bolts and other exposed metal objects attached thereto that are associated with communication line equipment.

EXCEPTION: Vertical runs of effectively grounded supply conductors may have a clearance of 25 mm (1 in).

H. Requirements for vertical communication conductors passing through supply space on jointly used structures

All vertical runs of communication conductors passing through supply space shall be installed as follows:

1. Metal-sheathed communication cables

Vertical runs of metal-sheathed communication cables shall be covered with suitable nonmetallic material, where they pass trolley feeders or other supply line conductors. This nonmetallic covering shall extend from a point 1.0 m (40 in) above the highest trolley feeders or other supply conductors, to a point 1.80 m (6 ft) below the lowest trolley feeders or other supply conductors, but need not extend below the top of any mechanical protection that may be provided near the ground.

EXCEPTION 1: Communication cables may be run vertically on the pole through space occupied by railroad signal supply circuits in the lower position, as permitted in Rule 220B2, without covering within the supply space.

EXCEPTION 2: Covering is not required in the supply space on metallic or concrete supporting structures.

EXCEPTION 3: Where the cable terminates at an antenna in the supply space meeting Rule 235I, the nonmetallic covering need only extend to the antenna.

2. Communication conductors

Vertical runs of insulated communication conductors shall be covered with suitable nonmetallic material, to the extent required for metal-sheathed communication cables in Rule 239H1, where such conductors pass trolley feeders or supply conductors.

EXCEPTION 1: Communication conductors may be run vertically on the structure through space occupied by railroad-signal supply circuits in the lower position, as permitted in Rule 220B2, without covering within the supply space.

EXCEPTION 2: Covering is not required in the supply space on metallic or concrete supporting structures.

EXCEPTION 3: Where the conductor terminates at an antenna in the supply space meeting Rule 235I, the nonmetallic covering need only extend to the antenna bracket.

3. Communication grounding conductors

Vertical communication grounding conductors shall be covered with suitable nonmetallic material between points at least 1.80 m (6 ft) below and 1.0 m (40 in) above any trolley feeders or other supply line conductors by which they pass.

EXCEPTION 1: Communication grounding conductors may be run vertically on the structure though space occupied by railroad-signal supply circuits in the lower position, as permitted in Rule 220B2, without covering within the supply space.

EXCEPTION 2: Covering is not required in the supply space on metallic or concrete supporting structures.

EXCEPTION 3: Where the grounding conductor terminates at an antenna in the supply space meeting Rule 235I, the nonmetallic covering need only extend to the antenna bracket.

4. Clearance from through bolts and other metal objects

Vertical runs of communication conductors or cables shall have a clearance of one eighth of the pole circumference but not less than 50 mm (2 in) from exposed through bolts and other exposed metal objects attached thereto that are associated with supply line equipment.

EXCEPTION: Vertical runs of effectively grounded communication cables may have a clearance of 25 mm (1 in).

I. Operating rods

Effectively grounded or insulated operating rods of switches are permitted to pass through the communication space, but shall be located outside of the climbing space.

J. Additional rules for standoff brackets

1. Standoff brackets may be used to support the conduit(s). Cable insulation appropriate for the intended service is required; non-metallic conduit shall not be used to meet basic insulation requirements.

   NOTE: See Rule 217A2.

2. Standoff brackets may be used to support the following types of cable enclosed within a single outer jacket or sheath (cable only without conduit):

   a. Communication

   b. 230C1a supply (any voltage)

   c. Supply less than 750 V

   NOTE: See Rule 217A2.

mm

Table 239-1—Clearance of open vertical and lateral conductors
(Circuit phase-to-phase voltage. See also Rules 239E1 and 239E2b.)

Clearance of open vertical and lateral conductors	Neutral conductors meeting Rule 230E1	0 to 8.7 kV ⑦ (mm)	Over 8.7 kV to 50 kV (mm)	Over 50 kV ④ (mm)
From surfaces of supports	Not specified ①	75 ②	75 plus 5 per kV in excess of 8.7 kV ⑥	280 plus 5 per kV in excess of 50 kV
From span, guy, and messenger wires ⑤	75	150	150 plus 10 per kV in excess of 8.7 kV ③	580 plus 10 per kV in excess of 50 kV ③

①A neutral conductor meeting Rule 230E1 may be attached directly to the structure surface.
②For supply circuits of 0 to 750 V, this clearance may be reduced to 25 mm.
③Multiplier may be reduced to 6.5 mm/kV for anchor guys.
④The additional clearance for voltages in excess of 50 kV specified in Table 239-1 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
⑤These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
⑥Where the circuit neutral is effectively grounded and the neutral conductor meets Rule 230E1, phase-to-ground voltage may be used to determine the clearance from the surface of support arms and structures.
⑦Does not include neutral conductors meeting Rule 230E1.

Table 239-1—Clearance of open vertical and lateral conductors

(Circuit Phase-to-Phase Voltage. See also Rules 239E1 and 239E2b.)

Clearance of open vertical and lateral conductors	Neutral conductors meeting Rule 230E1	0 to 8.7 kV ⑦ (in)	Over 8.7 kV to 50 kV (in)	Over 50 kV ④ (in)
From surfaces of supports	Not specified ①	3 ②	3 plus 0.2 per kV in excess of 8.7 kV ⑥	11 plus 0.2 per kV in excess of 50 kV
From span, guy, and messenger wires ⑤	3	6	6 plus 0.4 per kV in excess of 8.7 kV ③	23 plus 0.4 per kV in excess of 50 kV ③

①A neutral conductor meeting Rule 230E1 may be attached directly to the structure surface.
②For supply circuits of 0 to 750 V, this clearance may be reduced to 1 in.
③Multiplier may be reduced to 0.25 in/kV for anchor guys.
④The additional clearance for voltages in excess of 50 kV specified in Table 239-1 shall be increased 3% for each 1000 ft in excess of 3300 ft above mean sea level.
⑤These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
⑥Where the circuit neutral is effectively grounded and the neutral conductor meets Rule 230E1, phase-to-ground voltage may be used to determine the clearance from the surface of support arms and structures.
⑦Does not include neutral conductors meeting Rule 230E1.

mm

Table 239-2—Clearance between open vertical conductors and pole surface

[Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.
See also Rules 239E2a(1) and 239E2a(2).]

Voltage (kV)	Distance above and below open supply conductors where clearances apply (m)	Clearance between vertical conductor and pole surface (mm)
0 to 22①	1.80	480
22 to 30	1.80	560
30 to 50	1.80	760

①Does not include neutral conductors meeting Rule 230E1.

in

Table 239-2—Clearance between open vertical conductors and pole surface

[Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.
See also Rules 239E2a(1) and 239E2a(2).]

Voltage (kV)	Distance above and below open supply conductors where clearances apply (ft)	Clearance between vertical conductor and pole surface (in)
0 to 22 ①	6	19
22 to 30	6	22
30 to 50	6	30

①Does not include neutral conductors meeting Rule 230E1.

Section 24.
Grades of construction

240. General

A. The grades of construction are specified in this section on the basis of the required strengths for safety. Where two or more conditions define the grade of construction required, the grade used shall be the highest one required by any of the conditions.

NOTE: For emergency or temporary installations, see Rule 014.

B. For the purposes of this section, the voltage values for direct-current circuits shall be considered equivalent to the rms values for alternating-current circuits.

241. Application of grades of construction to different situations

A. Supply cables

For the purposes of these rules, supply cables are classified by two types as follows:

Cable (Type 1)—Supply cables conforming to Rule 230C1, 230C2, or 230C3 shall be installed in accordance with Rule 261I.

Open (Type 2)—All other supply cables are required to have the same grade of construction as open-wire conductors of the same voltage.

B. Order of grades

The relative order of grades for supply and communication conductors and supporting structures is B, C, and N, with Grade B being the highest.

C. At crossings

1. Wires, conductors, or other cables of one line are considered to be at crossings when either:
   a. They cross over another line, whether or not on a common supporting structure.
   b. They cross over or overhang
      (1) A railroad track
      (2) The traveled way of a limited access highway, or
      (3) A navigable waterways requiring a waterway crossing permit.

   EXCEPTION: Joint-use or collinear construction in itself is not considered to be at crossings.

2. Grade of upper line

   Conductors and supporting structures of a line crossing over another line shall have the grade of construction specified in Rules 241C3, 242, and 243.

3. Grade of lower line

   Conductors and supporting structures of a line crossing under another line need only have the grades of construction that would be required if the line at the higher level were not there.

4. Multiple crossings
   a. Supply lines
      (1) Where a line crosses in one span over two or more other lines, the grade of construction of the uppermost line shall be not less than the highest grade required of any of the lower lines.
      (2) Where a line crosses over a span of a second line, which in turn crosses over a span of a third line, the grade of construction of the uppermost line shall be not less than the highest grade that would be required of either one of the lower lines.

b. Communication lines

Where communication conductors cross over supply conductors and railroad tracks in the same span, the grades of construction shall be in accordance with Grade B construction. It is recommended that the placing of communication conductors above supply conductors generally be avoided unless the supply conductors are trolley-contact conductors and their associated feeders.

D. Structure conflicts

The grade of construction of the conflicting structure shall be as required by Rule 243A4. (See Section 2, **structure conflict.**).

242. Grades of construction for conductors

The grades of construction required for conductors and cables are given in Table 242-1. For the purpose of this table certain classes of circuits are treated as follows:

A. Constant-current circuit conductors

The grade of construction for conductors of a constant-current supply circuit shall be based on the open-circuit voltage rating of the transformer supplying such circuit. The grade of construction shall be not less than that required in Table 242-1 for a supply conductor of the same voltage.

B. Railway feeder and trolley-contact circuit conductors

Railway feeder and trolley-contact circuit conductors shall be considered as supply conductors for the purpose of determining the required grade of construction.

C. Communication circuit conductors and cables

Communication circuit conductors and cables shall have a grade of construction not less than (a) that required by Table 242-1, or (b) the highest grade of construction required for any conductors or cables located below.

D. Fire-alarm circuit conductors

Fire-alarm circuit conductors shall meet the strength and loading requirements of communication circuit conductors.

E. Neutral conductors of supply circuits

Supply-circuit neutral conductors, which are effectively grounded throughout their length and are not located above supply conductors of more than 750 V to ground, shall have the same grade of construction as supply conductors of not more than 750 V to ground, except that they need not meet any insulation requirements. Other neutral conductors shall have the same grade of construction as the phase conductors of the supply circuits with which they are associated.

F. Surge-protection wires

Surge-protection wires shall be of the same grade of construction as the supply conductors with which they are associated.

Table 242-1— Grades of construction for conductors and cables alone, at crossing, or on the same structures with other conductors and cables

(The voltages listed in this table are phase-to-ground values for: effectively grounded ac circuits, two-wire grounded circuits, or center-grounded dc circuits; otherwise phase-to-phase values shall be used. The grade of construction for supply conductors and cables, as indicated across the top of the table, shall also meet the requirements for any lines at lower levels except when otherwise noted. Placing of communication conductors and cables at higher levels at crossings or on jointly used poles in a communication space above supply conductors or cables should generally be avoided, unless the supply conductors are trolley-contact conductors and their associated feeders.)

Conductors, cables, tracks, and rights-of-way at lower levels	Conductors and cables at higher levels [1]					
	Communication conductors and cables (including service drops)	Supply conductors				
		0 to 750 V (including service drops)	Over 750 V to 22 kV		Exceeding 22 kV	
	Open or cable	Open or cable	Cable	Open	Cable	Open
Exclusive private rights-of-way	N	N	N	N [2]	N [2]	N [2]
Common or public rights-of-way	N	N	N	C	C	B [3]
Railroad tracks and limited-access highways [10], and navigable waterways requiring waterway crossing permits	B	B	B	B	B	B
Communication conductor: open or cable [5] [11]	See Rule 242C	N	C	B [6] [7]	C	B [7]
Communication conductors: open or cable, located in the supply space [11]	See Rule 242C	See Rule 242C [9]				
Supply conductors, 0 to 750 V (including service drops) open or cable	N	N	N	C	C	B [3]
Over 750 V to 22 kV Cable	C	C [8]	N	C	C	B [3]
Over 750 V to 22 kV Open	B [6] [7]	C	C	C	C	B [3]

Table 242-1— *(continued)* Grades of construction for conductors and cables alone, at crossing, or on the same structures with other conductors and cables

(The voltages listed in this table are phase-to-ground values for: effectively grounded ac circuits, two-wire grounded circuits, or center-grounded dc circuits; otherwise phase-to-phase values shall be used. The grade of construction for supply conductors and cables, as indicated across the top of the table, shall also meet the requirements for any lines at lower levels except when otherwise noted. Placing of communication conductors and cables at higher levels at crossings or on jointly used poles in a communication space above supply conductors or cables should generally be avoided, unless the supply conductors are trolley-contact conductors and their associated feeders.)

Conductors, cables, tracks, and rights-of-way at lower levels	Conductors and cables at higher levels ①					
	Communication conductors and cables (including service drops)	Supply conductors				
		0 to 750 V (including service drops)	Over 750 V to 22 kV		Exceeding 22 kV	
	Open or cable	Open or cable	Cable	Open	Cable	Open
Exceeding 22 kV Cable	C	C⑧	N	C	C	B③
Exceeding 22 kV Open	B⑦	B	B	B	C	B③

①The words *open* and *cable* are defined in Rule 241A.

②Lines that can fall outside the exclusive private rights-of-way shall comply with the grades specified for lines not on exclusive private rights-of-way.

③Grade C construction may be used if the supply circuits will ~~not~~ be promptly de-energized, both initially and following subsequent breaker operations, in the event of a contact with lower supply conductors or other grounded objects.

④Not used in this edition.

⑤Grade N construction may be used where the communication conductors consist only of not more than one insulated twisted-pair or parallel-lay conductor, or where service drops only are involved.

⑥Grade C construction may be used if the voltage does not exceed 5.0 kV phase to phase or 2.9 kV phase to ground.

⑦Grade C construction may be used if both of the following conditions are fulfilled:

(a) The supply voltage will be promptly removed from the communications plant by de-energization or other means, both initially and following subsequent circuit-breaker operations in the event of a contact with the communications plant.

(b)The voltage and current impressed on the communications plant in the event of a contact with the supply conductors are not in excess of the safe operating limit of the communications-protective devices.

⑧For supply, Grade N may be used if both conductors and/or cables meet Rule 230C1, 230C2, or 230C3. These grades of construction apply to service drops as well as line conductors and cables.

⑨Communication circuits located below supply conductors shall not affect the grade of construction of the supply circuits.

⑩There is no intent to require Grade B over ordinary streets and highways.

⑪ For communication, Grade N may be used for entirely dielectric fiber-optic supply cables meeting Rule 230F1b, insulated communication cables located in the supply space and supported by an effectively grounded messenger, and for communication cables supported on messengers that are bonded at intervals specified in Rule 092C to supply messengers supporting cable meeting Rule 230C1, 230C2, or 230C3, or insulated communication cables supported by an effectively grounded messenger on communication-only structures and insulated self-supporting service drops. These grades of construction apply to communications service drops as well as cables.

243. Grades of construction for line supports

A. Structures

The grade of construction shall be that required for the highest grade of conductors supported except as modified by the following:

1. The grade of construction of jointly used structures, or structures used only by communication lines, need not be increased merely because the communication wires carried on such structures cross over trolley-contact conductors of 0 to 750 V to ground.
2. Structures carrying supply service drops of 0 to 750 V to ground shall have a grade of construction not less than that required for supply line conductors of the same voltage.
3. Where the communication lines cross over supply conductors and a railroad in the same span and Grade B is required by Rule 241C3b for the communication conductors, due to the presence of railroad tracks, the grade of the structures shall be B.
4. The grade of construction required for a conflicting structure (first circuit) shall be determined from the requirements of Rule 241, Rule 242, and Table 242-1 for crossings. The conflicting structure's conductors (first circuit) shall be assumed to cross the other circuit's conductors (second circuit) for the purposes of determining the grade of construction required for the conflicting structure.

   NOTE: The resulting structure grade requirement could result in a higher grade of construction for the structure than for the conductors carried thereon.

B. Crossarms and support arms

The grade of construction shall be that required for the highest grade of conductors carried by the arm concerned except as modified by the following:

1. The grade of construction of arms carrying only communication conductors need not be increased merely because the conductors cross over trolley-contact conductors of 0 to 750 V to ground.
2. Arms carrying supply service drops of 0 to 750 V to ground shall have a grade of construction not less than that required for supply line conductors of the same voltage.
3. Where communication lines cross over supply conductors and a railroad in the same span and Grade B is required by Rule 241C3b for the communication conductors due to the presence of railroad tracks, the grade of the arm shall be B.

C. Pins, armless construction brackets, insulators, and conductor fastenings

The grade of construction for pins, armless construction brackets, insulators, and conductor fastenings shall be that required for the conductor concerned except as modified by the following:

1. The grade of construction need not be increased merely because the supported conductors cross over trolley-contact conductors of 0 to 750 V to ground.
2. Supply service drops of 0 to 750 V to ground require only the same grade of construction as supply line conductors of the same voltage.
3. When Grade B construction is required by Rule 241C3b for the communication conductors due to the presence of railroad tracks, Grade B construction shall be used when supporting communication lines that cross over supply conductors and a railroad in the same span.
4. Insulators for use on open conductor supply lines shall meet the requirements of Section 27 for all grades of construction.

Section 25.
Loadings for Grades B and C

250. General loading requirements and maps

A. General

1. It is necessary to assume the wind and ice loads that may occur on a line. The intent of the NESC rules is to apply wind loading in an essentially horizontal plane. Three weather loadings are specified in Rules 250B, 250C, and 250D. Where all three rules apply, the required loading shall be the one that has the greatest effect.

2. Where construction or maintenance loads exceed those imposed by Rule 250A1, the assumed loadings shall be increased accordingly. When temporary loads, such as lifting of equipment, stringing operations, or a worker on a structure or its component, are to be imposed on a structure or component, the strength of the structure or component should be taken into account or other provisions should be made to limit the likelihood of adverse effects of structure or component failure.

   NOTE: Other provisions could include cranes that can support the equipment loads, guard poles and spotters with radios, and stringing equipment capable of promptly halting stringing operations.

3. It is recognized that loadings actually experienced in certain areas in each of the loading districts may be greater, or in some cases, may be less than those specified in these rules. In the absence of a detailed loading analysis, using the same respective statistical methodologies used to develop the maps in Rule 250C or 250D, no reduction in the loadings specified therein shall be made without the approval of the administrative authority.

4. The structural capacity provided by meeting the loading and strength requirements of Sections 25 and 26 provides sufficient capability to resist earthquake ground motions.

B. Combined ice and wind district loading

Four general degrees of district loading due to weather conditions are recognized and are designated as heavy, medium, light, and warm island loadings. Figure 250-1 shows the districts where these loadings apply. Warm island loading applies to islands located from latitude 25 degrees south through 25 degrees north.

NOTE: The localities are classified in the different loading districts according to the relative simultaneous prevalence of the wind velocity and thickness of ice that accumulates on wires. Light loading is for places where little, if any, ice accumulates on wires. In the warm island loading zone, cold temperatures and ice accumulation on wires only occurs at high altitudes.

Table 250-1 shows the radial thickness of ice and the wind pressures to be used in calculating loads. Ice is assumed to weigh 913 kg/m^3 (57 lb/ft^3).

C. Extreme wind loading

If no portion of a structure or its supported facilities exceeds 18 m (60 ft) above ground or water level, the provisions of this rule are not required, except as specified in Rule 261A1c, 261A2e, or 261A3d. Where a structure or its supported facilities exceeds 18 m (60 ft) above ground or water level the structure and its supported facilities shall be designed to withstand the extreme wind load associated with the Basic Wind Speed, as specified by Figure 250-2. The wind pressures calculated shall be applied to the entire structure and supported facilities without ice. The following formula shall be used to calculate wind load.

NOTE: The commentary to ASCE 7-10 indicates that these wind speeds represent a 50-to-90 year mean recurrence interval.

Load in newtons = $0.613 \cdot (V_{m/s})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f \cdot A(m^2)$

Load in pounds = $0.00256 \cdot (V_{mi/h})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f \cdot A(ft^2)$

where

0.613 0.00256	Velocity-pressure numerical coefficient reflects the mass density of air for the standard atmosphere, i.e., temperature of 15 °C (59 °F) and sea level pressure of 760 mm (29.92 in) of mercury. The numerical coefficient 0.613 metric (0.00256 customary) shall be used except where sufficient climatic data are available to justify the selection of a different value of this factor for a design application.
k_z	Velocity pressure exposure coefficient, as defined in Rule 250C1, Table 250-2
V	Basic wind speed, 3 s gust wind speed in m/s at 10 m (mi/h at 33 ft) aboveground, Figure 250-2
G_{RF}	Gust response factor, as defined in Rule 250C2
I	Importance factor, 1.0 for utility structures and their supported facilities
C_f	Force coefficient (shape factor). As defined in Rules 251A2 and 252B
A	Projected wind area, m^2 (ft^2)

The wind pressure parameters (k_z, V, and G_{RF}) are based on open terrain with scattered obstructions (Exposure Category C as defined in ASCE 7-10). Exposure Category C is the basis of the NESC extreme wind criteria. Topographical features such as ridges, hills, and escarpments may increase the wind loads on site-specific structures. A Topographic Factor, K_{zt}, from ASCE 7-10, may be used to account for these special cases.

NOTE: Special wind regions—Although the wind speed map is valid for most regions of the country, special wind regions indicated on the map are known to have wind speed anomalies. Winds blowing over mountain ranges or through gorges or river valleys in these special regions can develop speeds that are substantially higher than the values indicated on the map.

1. Velocity pressure exposure coefficient, k_z

   The velocity pressure exposure coefficient, k_z, is based on the height, h, to the center-of-pressure of the wind area for the following load applications:

   a. k_z for the structure is based on 0.67 of the total height, h, of the structure aboveground line.

      NOTE: In Table 250-2, for h ≤ 75 m (250 ft), the structure k_z values are adjusted for the wind load to be determined at the center-of-pressure of the structure assumed to be at 0.67 h. The wind pressure is assumed uniformly distributed over the structure face normal to the wind.

   b. k_z for the wire is based on the height, h, of the wire at the structure.

      In special terrain conditions (i.e., mountainous terrain and canyon) where the height of the wire aboveground anywhere in the span may be substantially higher than at the structure, engineering judgment may be used in determining an appropriate value for the wire k_z.

   c. k_z for a specific height on a structure or component is based on the height, h, to the center-of-pressure of the wind area being considered.

      The formulas shown in Table 250-2 shall be used to determine all values of k_z.

      EXCEPTION: The selected values of k_z tabulated in Table 250-2 may be used instead of calculating the values.

2. Gust response factor, G_{RF}

   a. The structure gust response factor, G_{RF}, is determined using the total structure height, h. When calculating a wind load at a specific height on a structure, the structure gust response factor, G_{RF}, determined using the total structure height, h, shall be used.

   b. The wire gust response factor is determined using the height of the wire at the structure, h, and the span length, L. Wire attachment points that are 18 m (60 ft) or less above ground or water level must be considered if the total structure height is greater than 18 m (60 ft) above ground or water.

In special terrain conditions (i.e., mountainous terrain and canyon) where the height of the wire aboveground at mid-span may be substantially higher than at the attachment point, engineering judgment may be used in determining an appropriate value for the wire G_{RF}.

c. The gust response factor, G_{RF}, to be used on components, such as antennas, transformers, etc., shall be the structure gust response factor determined in Rule 250C2a.

Selected values of the structure and wire gust response factors are tabulated in Table 250-3. The structure and wire gust response factors may also be determined using the formulas in Table 250-3. For values of $h > 75$ m (250 ft) and $L > 600$ m (2000 ft), the G_{RF} shall be determined using the formulas in Table 250-3.

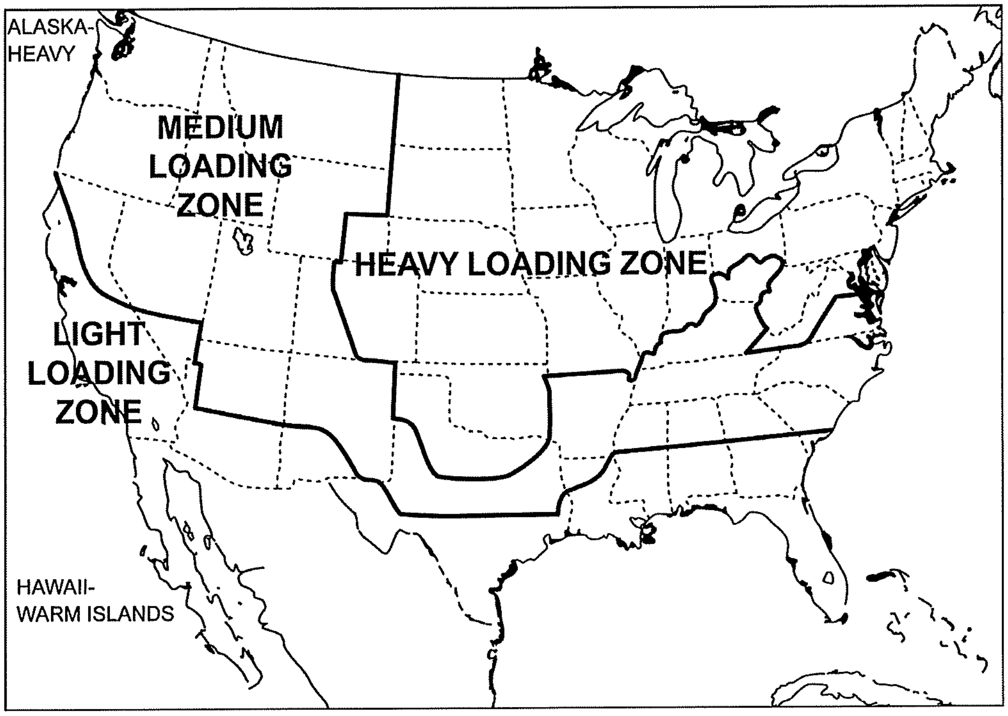
NOTE: Where structure heights are 50 m (165 ft) or less and spans are 600 m (2000 ft) or less, the combined product of k_z and G_{RF} may be conservatively taken as 1.15 if it is desired to simplify calculations.

D. Extreme ice with concurrent wind loading

If no portion of a structure or its supported facilities exceeds 18 m (60 ft) above ground or water level, the provisions of this rule are not required. Where a structure or its supported facilities exceeds 18 m (60 ft) above ground or water level, the structure and its supported facilities shall be designed to withstand loads associated with the Uniform Ice Thickness and Concurrent Wind Speed, as specified by Figure 250-3. The wind pressures for the concurrent wind speed shall be as indicated in Table 250-4. The wind pressures calculated shall be applied without ice to the entire structure and to all supported facilities without ice other than wires, conductors, cables, and messengers and to the iced diameters of wires, conductors, cables, and messengers determined in accordance with Rule 251. Vertical loads due to radial ice shall be computed on wires, conductors, cables, and messengers but need not be computed on the structure and other supported facilities. No loading is specified in this rule for extreme ice with concurrent wind loading for warm islands located from 25 degrees latitude south through 25 degrees latitude north.

Ice is assumed to weigh 913 kg/m^3 (57 lb/ft^3).

1. For Grade B, the radial thickness of ice from Figure 250-3 shall be multiplied by a factor of 1.00.
2. For Grade C, the radial thickness of ice from Figure 250-3 shall be multiplied by a factor of 0.80.
3. The concurrent wind shall be applied to the projected area resulting from Rules 250D1 and 250D2 multiplied by a factor of 1.00.



The Warm Island Loading District includes American Samoa, Guam, Hawaii, Puerto Rico, Virgin Islands, and other islands located from 0 to 25 degrees latitude, north or south.

Figure 250-1—General loading map of United States with respect to loading of overhead lines

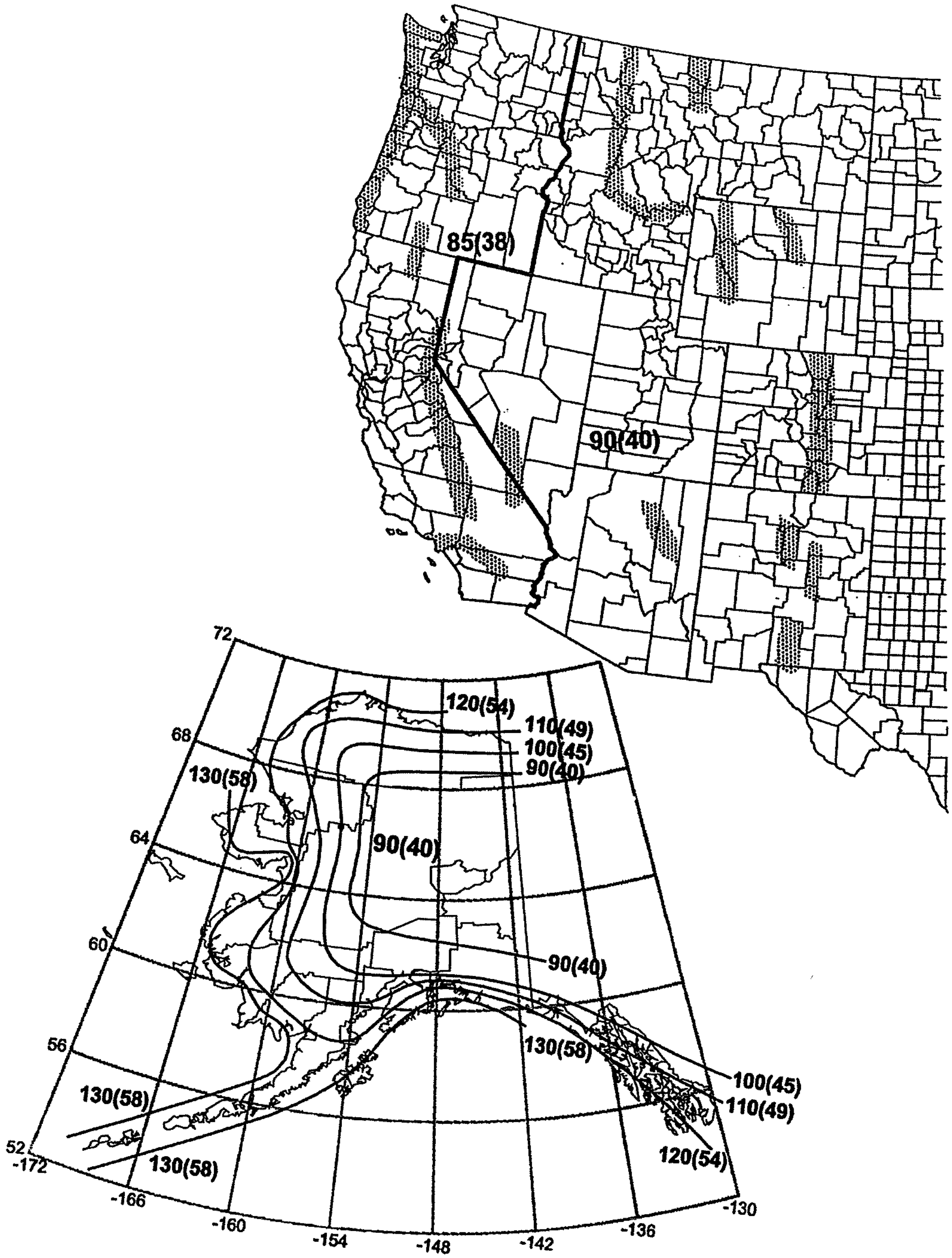


Figure 250-2(a)—Basic wind speeds

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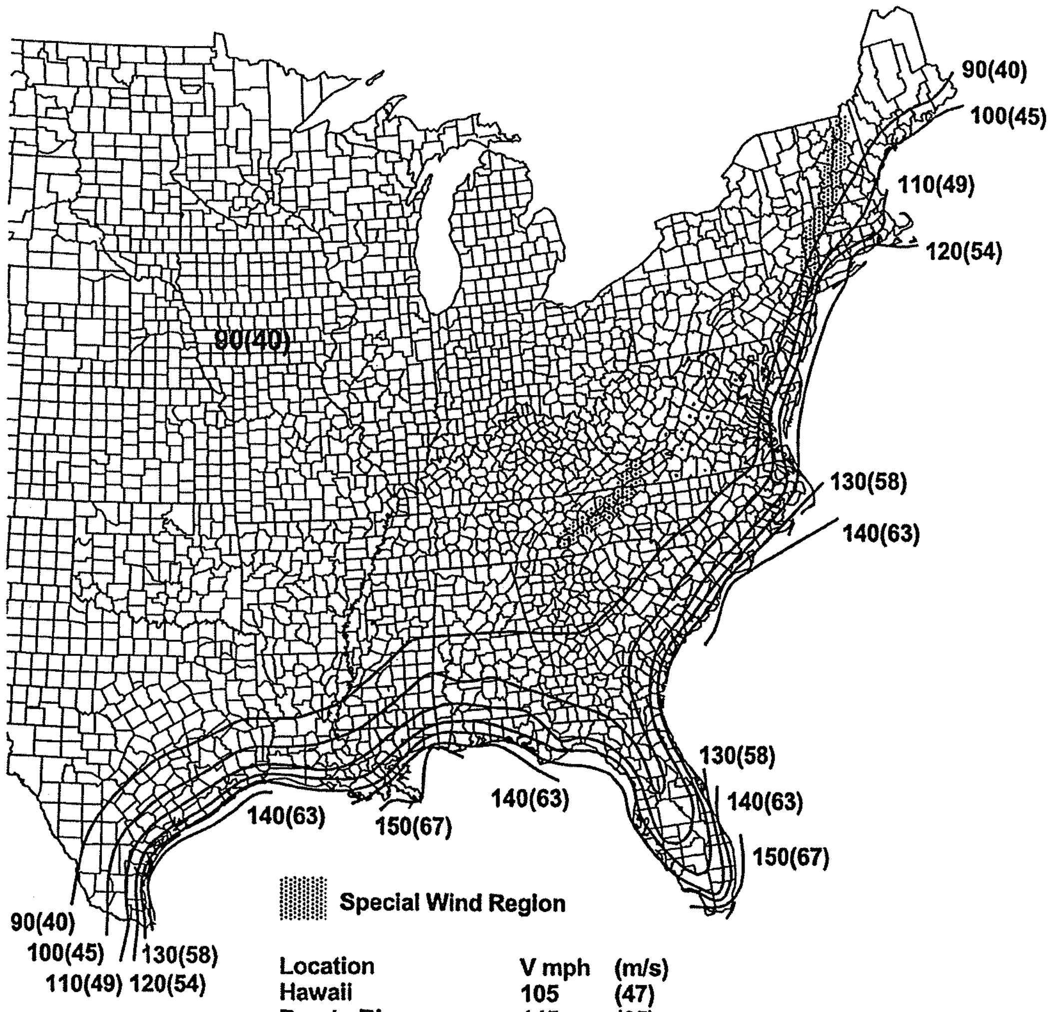

Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

Notes:

1. **Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.**
2. **Linear interpolation between wind contours is permitted.**
3. **Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.**
4. **Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.**

Figure 250-2(b)—Basic wind speeds

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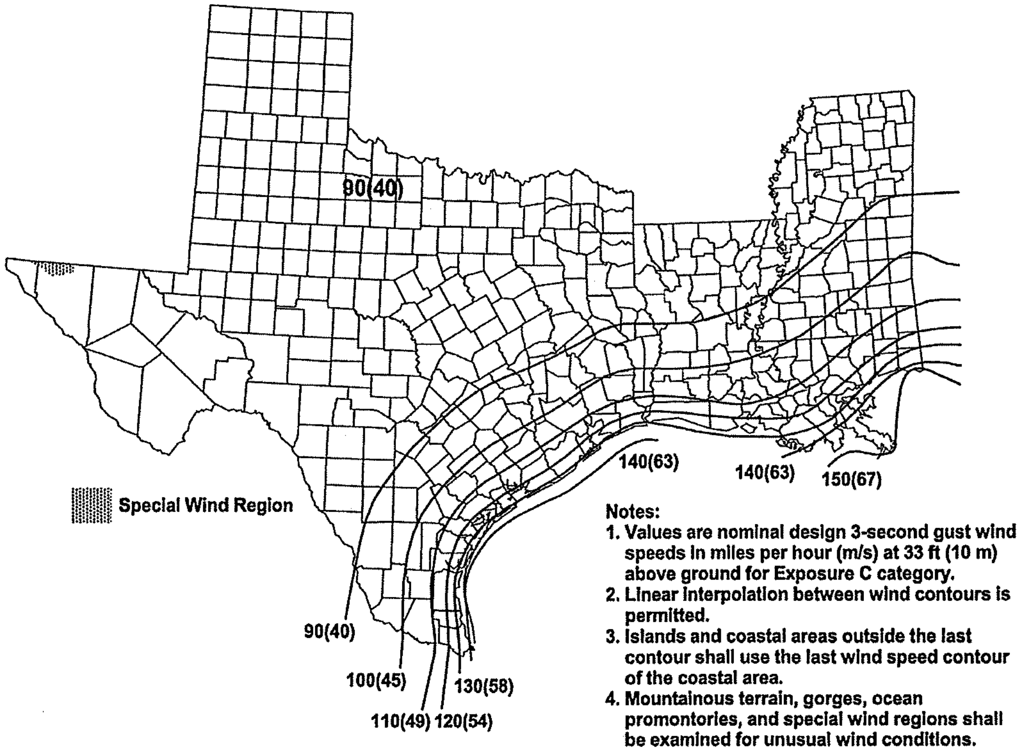

Figure 250-2(c)—Western Gulf of Mexico hurricane coastline

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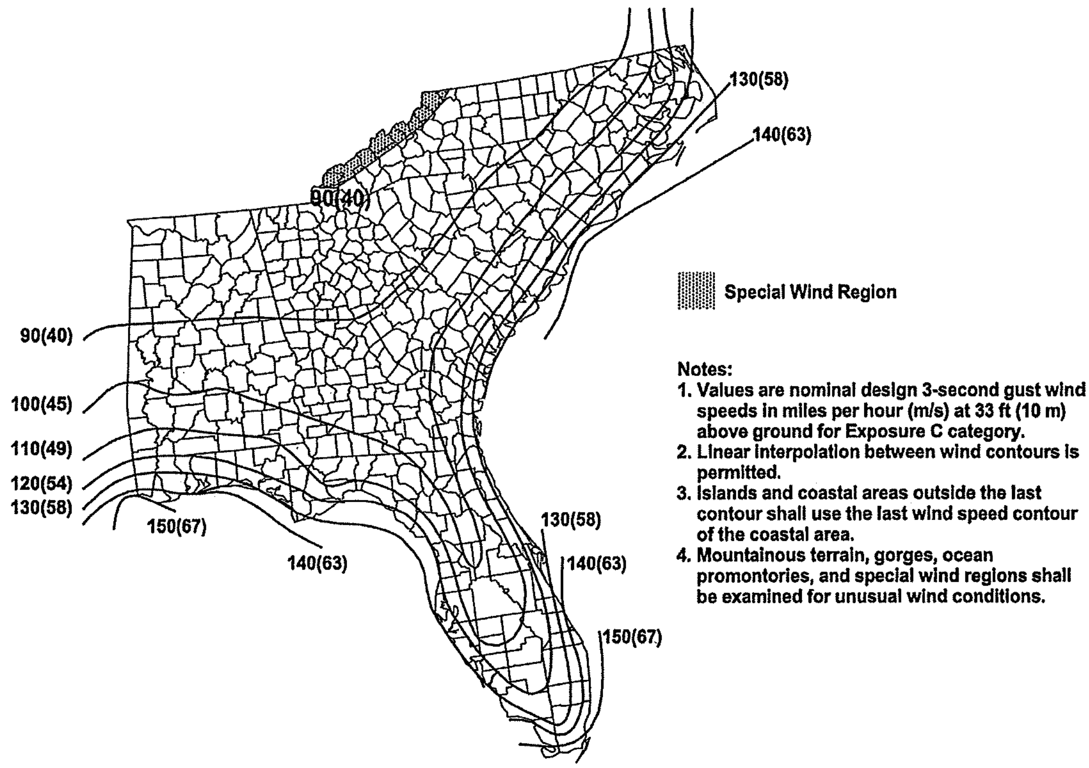

Figure 250-2(d)—Eastern Gulf of Mexico and southeastern U.S. hurricane coastline

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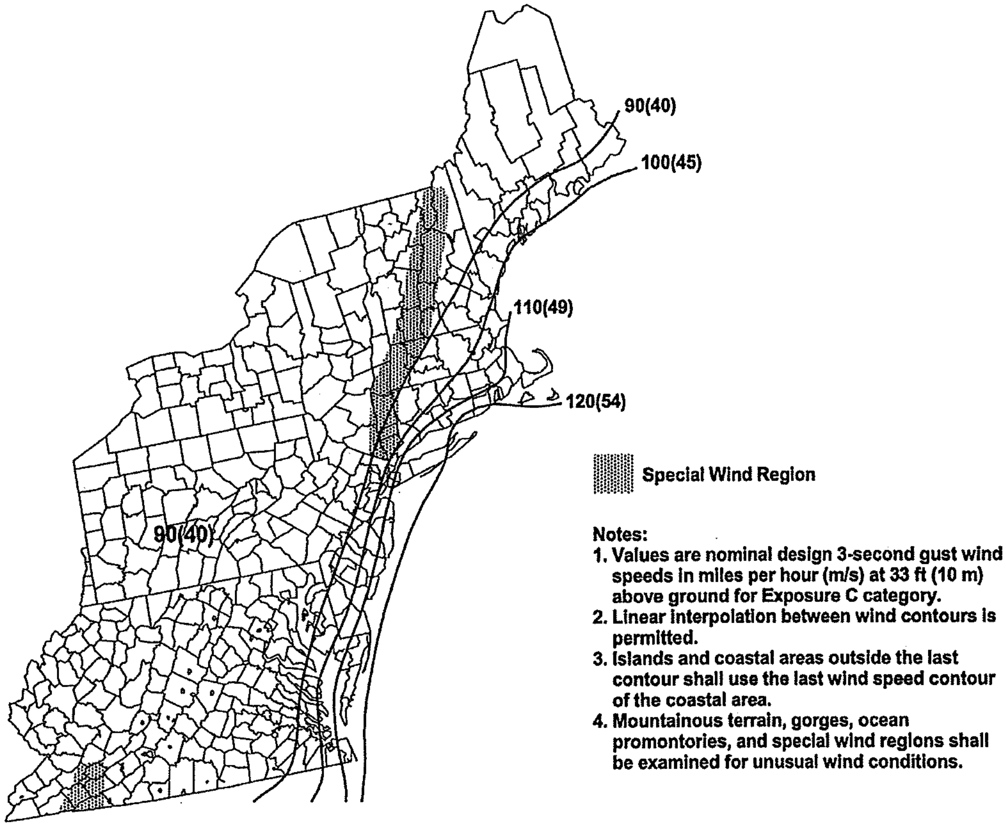

Figure 250-2(e)—Mid and northern Atlantic hurricane coastline

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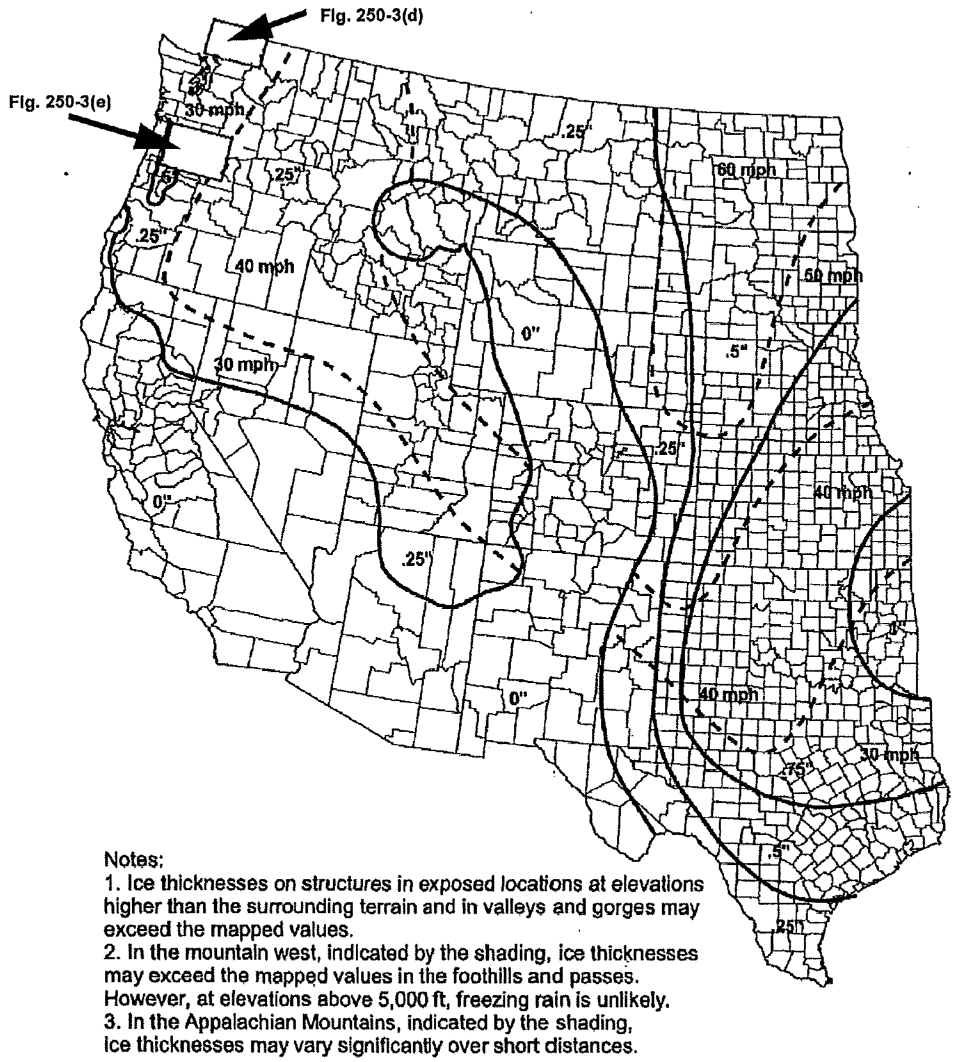

50-YEAR MEAN RECURRENCE INTERVAL UNIFORM ICE THICKNESSES DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST SPEEDS: CONTIGUOUS 48 STATES.

Figure 250-3(a)—Uniform ice thickness with concurrent wind

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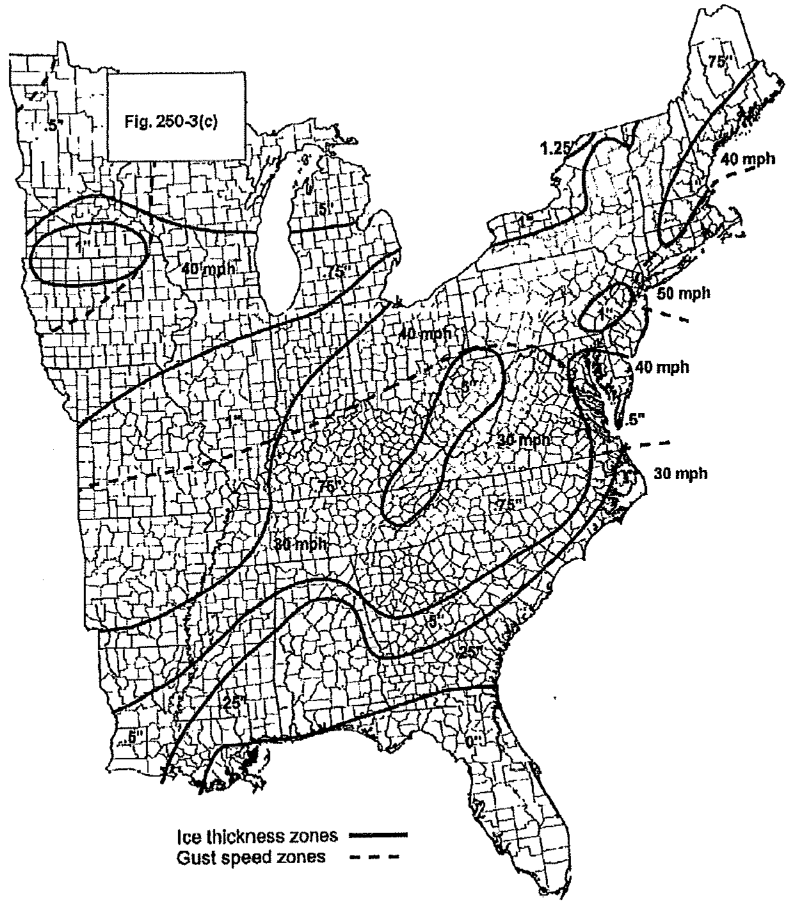

50-YEAR MEAN RECURRENCE INTERVAL UNIFORM ICE THICKNESSES DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST SPEEDS: CONTIGUOUS 48 STATES.

Figure 250-3(b)—Uniform ice thickness with concurrent wind

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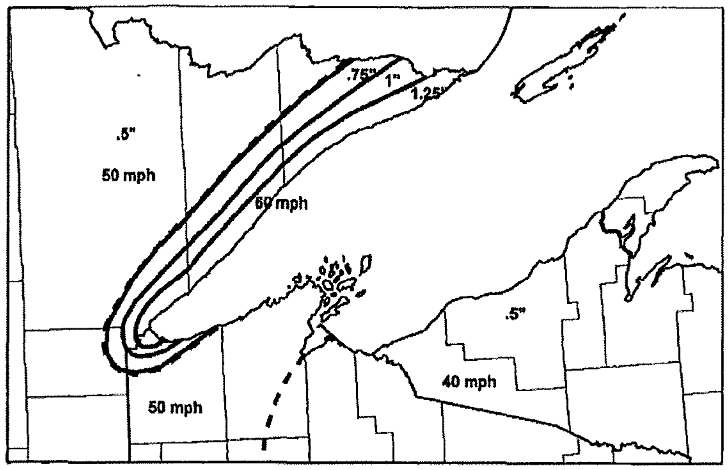

LAKE SUPERIOR DETAIL

Figure 250-3(c)—Uniform ice thickness with concurrent wind

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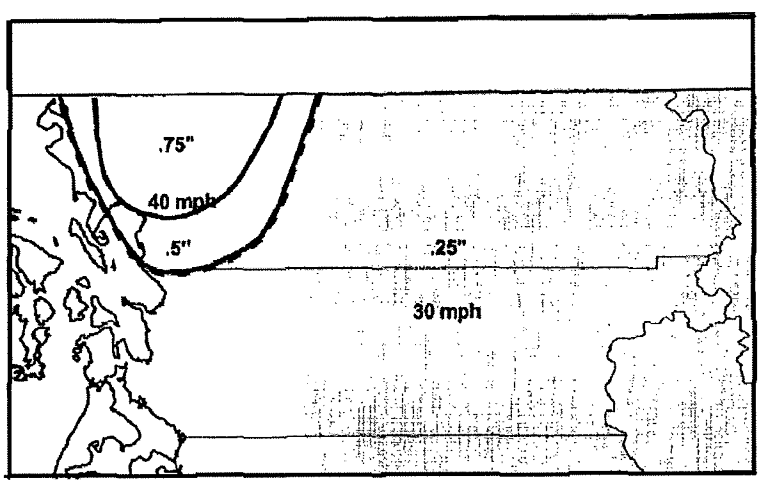

FRASER VALLEY, WASHINGTON DETAIL

Figure 250-3(d)—Uniform ice thickness with concurrent wind

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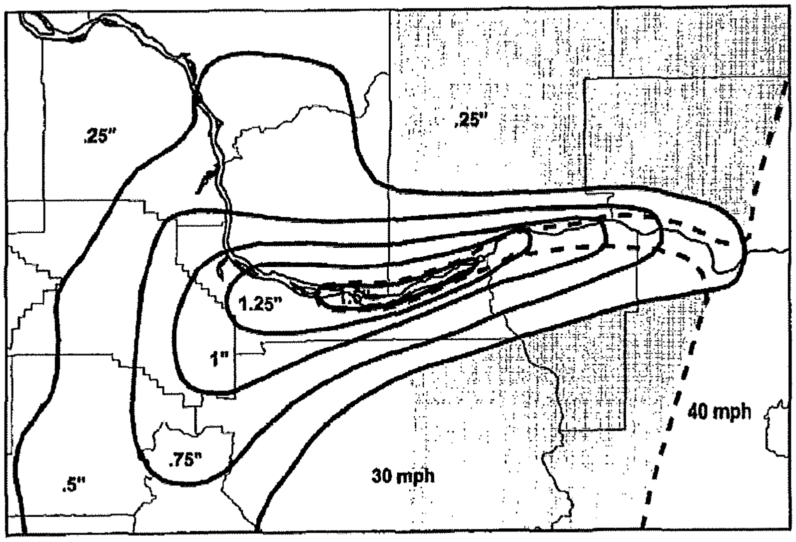

COLUMBIA RIVER GORGE, WASHIIGTOII DETAIL

Figure 250-3(e)—Uniform ice thickness with concurrent wind

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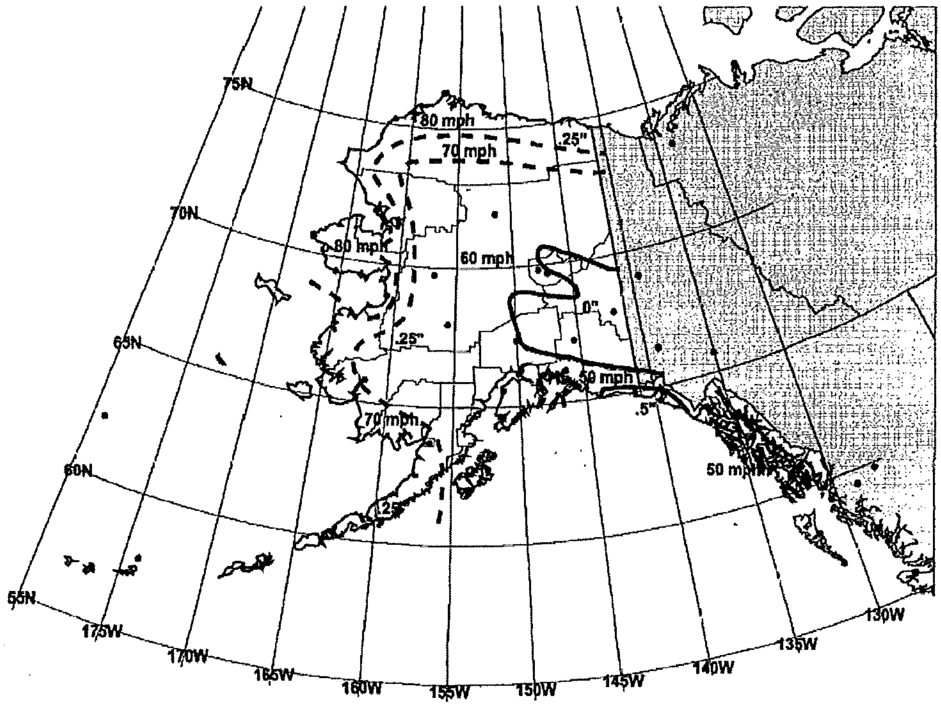

Figure 250-3(f)—Uniform ice thickness with concurrent wind

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Table 250-1—Ice, wind pressures, and temperatures

	Loading districts (for use with Rule 250B)					Extreme wind loading (for use with Rule 250C)	Extreme ice loading with concurrent wind (for use with Rule 250D)
	Heavy see Figure 250-1	Med-ium see Figure 250-1	Light see Figure 250-1	Warm islands [①]			
				Altitudes sea level to 2743 m (9000 ft)	Altitudes above 2743 m (9000 ft)		
Radial thickness of ice							
(mm)	12.5	6.5	0	0	6.5	0	See Figure 250-3
(in)	0.50	0.25	0	0	0.25	0	See Figure 250-3
Horizontal wind pressure							
(Pa)	190	190	430	430	190	See Figure 250-2	See Figure 250-3
(lb/ft2)	4	4	9	9	4	See Figure 250-2	See Figure 250-3
Temperature							
(°C)	–20	–10	–1	+10	–10	+15	–10
(°F)	0	+15	+30	+50	+15	+60	+15

[①] Warm islands located from latitude 25 degrees south through 25 degrees north include American Samoa (14°S), Guam (13°N), Hawaii (22°N), Puerto Rico (18°N), and Virgin Islands (18°N).

Table 250-2—Velocity pressure exposure coefficient k_z

Height, h (m)	Height, h (ft)	k_z (structure)	k_z (wire, specified height on the structure, and component)
≤ 10	≤ 33	0.9	1.0
> 10 to 15	> 33 to 50	1.0	1.1
> 15 to 25	> 50 to 80	1.1	1.2
> 25 to 35	> 80 to 115	1.2	1.3
> 35 to 50	> 115 to 165	1.3	1.4
> 50 to 75	> 165 to 250	1.4	1.5
> 75	> 250	Use formulas	Use formulas

Formulas (metric):

Structure	$k_z = 2.01 \cdot (0.67 \cdot h/275)^{(2/9.5)}$	$h \leq 275$ m
	$k_z = 1.85$	$h > 275$ m
Wire, specified height on the structure, and component	$k_z = 2.01 \cdot (h/275)^{(2/9.5)}$	$h \leq 275$ m
	$k_z = 2.01$	$h > 275$ m

Formulas (customary):

Structure	$k_z = 2.01 \cdot (0.67 \cdot h/900)^{(2/9.5)}$	$h \leq 900$ ft
	$k_z = 1.85$	$h > 900$ ft
Wire, specified height on the structure, and component	$k_z = 2.01 \cdot (h/900)^{(2/9.5)}$	$h \leq 900$ ft
	$k_z = 2.01$	$h > 900$ ft

h = Structure, specified height on the structure, and component and wire height as defined in Rule 250C1

Minimum $k_z = 0.85$

Formulas are for Exposure Category C, ASCE 7-10.

NOTE: Calculations in this table are based on the maximum values in the stated ranges.

m

Table 250-3—Structure and wire gust response factors, G_{RF}

Height	Structure	Wire G_{RF}, span length, L (m)						
h (m)	G_{RF}	≤75	75<L≤150	150<L≤225	225<L ≤300	300<L ≤450	450<L ≤600	L >600
≤ 10	1.00	0.91	0.86	0.79	0.75	0.72	0.69	①
> 10 to 15	0.96	0.87	0.82	0.76	0.73	0.70	0.67	①
> 15 to 25	0.93	0.85	0.80	0.75	0.71	0.69	0.66	①
> 25 to 35	0.89	0.82	0.78	0.73	0.70	0.68	0.65	①
> 35 to 50	0.86	0.81	0.77	0.72	0.69	0.67	0.64	①
> 50 to 75	0.83	0.79	0.75	0.71	0.68	0.66	0.63	①
> 75	①	①	①	①	①	①	①	①

Formulas:

Structure $G_{RF} = [1 + (2.7 \cdot E_s \cdot B_s^{0.5})]/k_v^2$

Wire $G_{RF} = [1 + (2.7 \cdot E_w \cdot B_w^{0.5})]/k_v^2$

$E_s = 0.346 \cdot [10/(0.67 \cdot h)]^{1/7}$

$E_w = 0.346 \cdot (10/h)^{1/7}$

$B_s = 1/(1 + 0.56 \cdot (0.67 \cdot h)/67)$

$B_w = 1/(1 + 0.8 \cdot L/67)$

Where:

E_w = Wire exposure factor

E_s = Structure exposure factor

B_w = Dimensionless response term corresponding to the quasi-static background wind loads on the wire

B_s = Dimensionless response term corresponding to the quasi-static background wind loads on the structure

$k_v = 1.43$

h = Structure or wire height, as defined in Rule 250C2, in meters

L = Design wind span, in meters

Formulas are for Exposure Category C, ASCE 7-10.

①For heights greater than 75 m and/or spans greater than 600 m, the formulas shall be used.

Table 250-4—Wind speed conversions to pressure
To be used only with the extreme ice with concurrent wind loading of Rule 250D and Figure 250-3.

Wind speed (mph)	Horizontal wind pressure	
	Pascals	lb/ft^2
30	110	2.3
40	190	4.0
50	310	6.4
60	440	9.2
70	600	12.5
80	780	16.4

251. Conductor loading

A. General

Ice and wind loads are specified in Rule 250.

1. Where a cable is attached to a messenger, the specified loads shall be applied to both cable and messenger.

2. In determining wind loads on a conductor or cable without ice covering, the assumed projected area shall be that of a smooth cylinder whose outside diameter is the same as that of the conductor or cable. The force coefficient (shape factor) for cylindrical surfaces is assumed to be 1.0.

   EXCEPTION: The force coefficient (shape factor) of 1.0 may be reduced for the bare conductor (without radial ice) if wind tunnel tests or a qualified engineering study justifies a reduction.

   NOTE: Experience has shown that as the size of multiconductor cable decreases, the actual projected area decreases, but the roughness factor increases and offsets the reduction in projected area.

3. An appropriate mathematical model shall be used to determine the wind and weight loads on ice-coated conductors and cables. In the absence of a model developed in accordance with Rule 251A4, the following mathematical model shall be used:

   a. On a conductor, lashed cable, or multiple-conductor cable, the coating of ice shall be considered to be a hollow cylinder touching the outer strands of the conductor or the outer circumference of the lashed cable or multiple-conductor cable.

   b. On bundled conductors, the coating of ice shall be considered as individual hollow cylinders around each subconductor.

4. It is recognized that the effects of conductor stranding or of non-circular cross section may result in wind and ice loadings more or less than those calculated according to assumptions stated in Rules 251A2 and 251A3. No reduction in these loadings is permitted unless testing or a qualified engineering study justifies a reduction.

B. Load components

The load components shall be determined as follows:

1. Vertical load component

   The vertical load on a wire, conductor, or messenger shall be its own weight plus the weight of conductors, spacers, or equipment that it supports, ice covered where required by Rule 250.

ft

Table 250-3—Structure and wire gust response factors, G_{RF}

Height	Structure	Wire G_{RF}, span length, L (ft)						
h (ft)	G_{RF}	≤250	250<L ≤500	500<L ≤750	750<L ≤1000	1000<L ≤1500	1500<L ≤2000	L> 2000①
≤ 33	1.02	0.93	0.86	0.79	0.75	0.73	0.69	①
> 33 to 50	0.97	0.88	0.82	0.76	0.72	0.70	0.67	①
> 50 to 80	0.93	0.86	0.80	0.75	0.71	0.69	0.66	①
> 80 to 115	0.89	0.83	0.78	0.73	0.70	0.68	0.65	①
> 115 to 165	0.86	0.82	0.77	0.72	0.69	0.67	0.64	①
> 165 to 250	0.83	0.80	0.75	0.71	0.68	0.66	0.63	①
> 250	①	①	①	①	①	①	①	①

Formulas:

Structure $G_{RF} = [1 + (2.7 \cdot E_s \cdot B_s^{0.5})]/k_v^2$

Wire $G_{RF} = [1 + (2.7 \cdot E_w \cdot B_w^{0.5})]/k_v^2$

$E_s = 0.346 \cdot [33/(0.67 \cdot h)]^{1/7}$

$E_w = 0.346 \cdot (33/h)^{1/7}$

$B_s = 1/(1 + 0.56 \cdot (0.67 \cdot h)/220)$

$B_w = 1/(1 + 0.8 \cdot L/220)$

Where:

E_w = Wire exposure factor

E_s = Structure exposure factor

B_w = Dimensionless response term corresponding to the quasi-static background wind loads on the wire

B_s = Dimensionless response term corresponding to the quasi-static background wind loads on the structure

$k_v = 1.43$

h = Structure or wire height, as defined in Rule 250C2, in feet

L = Design wind span, in feet

Formulas are for Exposure Category C, ASCE 7-10.

①For heights greater than 250 ft and/or spans greater than 2000 ft, the formulas shall be used.

2. Horizontal load component

The horizontal load shall be the horizontal wind pressure of determined under Rule 250 applied at right angles to the direction of the line using the projected area of the conductor or messenger and conductors spacers, or equipment that it supports, ice covered where required by Rule 250.

NOTE: The projected area of the conductor or messenger is equal to the diameter of the conductor or messenger, plus ice if appropriate, multiplied by the span length (see Rule 252B4). See Rule 251A2 for force coefficient values of different surface shapes.

3. Total load

The total load on each wire, conductor, or messenger shall be the resultant of components 1 and 2 above, calculated at the applicable temperature in Table 251-1, plus the corresponding additive constant in Table 251-1. In all cases the conductor or messenger tension shall be computed from this total load.

Table 251-1—Temperatures and constants

	Loading districts (for use with 250B)					Extreme wind loading (for use with Rule 250C)	Extreme ice loading with concurrent wind (for use with Rule 250D)
	Heavy (see Figure 250-1)	Medium (see Figure 250-1)	Light (see Figure 250-1)	Warm islands ① Altitudes sea level to 2743 m (9000 ft)	Warm islands ① Altitudes above 2743 m (9000 ft)		
Temperature							
(°C)	–20	–10	–1	+10	–10	+15	–10
(°F)	0	+15	+30	+50	+15	+60	+15
Constant to be added to the resultant (all conductors) ②							
(N/m)	4.40	2.90	0.73	0.73	2.90	0.0	0.0
(lb/ft)	0.30	0.20	0.05	0.05	0.20	0.0	0.0

① Warm islands located from latitude 25 degrees south through 25 degrees north include American Samoa (14°S), Guam (13°N), Hawaii (22°N), Puerto Rico (18°N), and Virgin Islands (18°N).

② For cable arrangements supported by a messenger using spacers or rings and where each conductor or cable is separately loaded with ice and wind as described in Rule 251A3b (as opposed to being analyzed with the ice and wind applied to a hollow cylinder touching the outer strands of the conductors as described in Rule 251A3a), the constant specified here shall be added to the resultant load of each component conductor and the messenger.

252. Loads on line supports

A. Assumed vertical loads

The vertical loads on poles, towers, foundations, crossarms, pins, insulators, and conductor fastenings shall be their own weight plus the weight that they support, including all wires and cables, in accordance with Rules 251A and 251B1, together with the effect of any difference in elevation of supports. Loads due to radial ice shall be computed on wires, cables, and messengers, but need not be computed on supports.

B. Assumed transverse loads

The total transverse loads on poles, towers, foundations, crossarms, pins, insulators, and conductor fastenings shall include the following:

1. Transverse loads from conductors and messengers

The transverse loads from conductors and messengers shall be the horizontal load determined by Rule 251.

EXCEPTION: In medium- and heavy-loading districts, where supporting structures carry ten or more conductors on the same crossarm, not including cables supported by messengers, and where the horizontal pin spacing does not exceed 380 mm (15 in), the transverse wind load may be calculated on two-thirds of the total number of such conductors if at least ten conductors are used in the calculations.

2. Wind loads on structures

The transverse load on structures and equipment shall be computed by applying, at right angles to the direction of the line, the appropriate horizontal wind pressure determined under Rule 250. This load shall be calculated using the projected surfaces of the structures and equipment supported thereon, without ice covering. The following force coefficient (shape factors) shall be used.

a. Cylindrical structures and components

Wind loads on straight or tapered cylindrical structures or structures composed of numerous narrow relatively flat panels that combine to form a total cross section that is circular or elliptical in shape shall be computed using a force coefficient (shape factor) of 1.0.

b. Flat surfaced (not latticed) structures and components

Wind loads on structures or components, having solid or enclosed flat sided cross sections that are square or rectangular, with rounded corners, shall be computed using a force coefficient (shape factor) of 1.6.

c. Latticed structures

Wind loads on square or rectangular latticed structures or components shall be computed using a force coefficient (shape factor) of 3.2 on the sum of the projected areas of the members of the front face if structural members are flat surfaced or 2.0 if structural surfaces are cylindrical. The total, however, need not exceed the load that would occur on a solid structure of the same outside dimension.

EXCEPTION: The force coefficient (shape factor) listed under Rules 252B2a, 252B2b, and 252B2c may be reduced if wind tunnel tests or a qualified engineering study justifies a reduction.

3. At angles

Where a change in direction of wires occurs, the loads on the structure, including guys, shall be the vector sum of the transverse wind load and the wire tension load. In calculating these loads, a wind direction shall be assumed that will give the maximum resultant load. Proper reduction may be made to the loads to account for the reduced wind pressure on the wires resulting from the angularity of the application of the wind on the wire.

4. Wind span

The calculated transverse load shall be based on the wind span, the average of the two spans adjacent to the structure concerned.

NOTE: For structures with wire terminations or with large line angles, engineering judgment may be used in determining the appropriate wind span.

C. Assumed longitudinal loading

1. Change in grade of construction

The longitudinal loads on supporting structures, including poles, towers, and guys at the ends of sections required to be of Grade B construction, when located in lines of lower than Grade B construction, shall be taken as an unbalanced tension in the direction of the higher grade section equal to the larger of the following values:

a. Conductors with rated breaking strength of 13.3 kN (3000 lb) or less

The unbalanced tension shall be the tension of two-thirds, but not fewer than two, of the conductors having a rated breaking strength of 13.3 kN (3000 lb) or less. The conductors selected shall produce the maximum stress in the support.

EXCEPTION: Where there are one or two conductors having rated breaking strength of 13.3 kN (3000 lb) or less, the load shall be that of one conductor.

b. Conductors with rated breaking strength of more than 13.3 kN (3000 lb)

The unbalanced tension shall be the tension resulting from one conductor when there are eight or fewer conductors (including overhead ground wires) having rated breaking strength of more than 13.3 kN (3000 lb), and the tension of two conductors when there are more than eight conductors. The conductors selected shall produce the maximum stress in the support.

2. Jointly used poles at crossings over railroads, communication lines, or limited access highways

Where a joint line crosses a railroad, a communication line, or a limited access highway, and Grade B is required for the crossing span, the tension in the communication conductors of the joint line shall be considered as limited to one-half their rated breaking strength, provided they are smaller than Stl WG No. 8 if of steel, or AWG No. 6 if of copper.

3. Deadends

The longitudinal load on a supporting structure at a deadend shall be an unbalanced pull equal to the tensions of all conductors and messengers (including overhead ground wires); except that with spans in each direction from the dead-end structure, the unbalanced pull shall be the difference in tensions.

4. Unequal spans and unequal vertical loads

The structure should be capable of supporting the unbalanced longitudinal load created by the difference in tensions in the wires in adjacent spans caused by unequal vertical loads or unequal spans.

5. Stringing loads

Consideration should be given to longitudinal loads that may occur on the structure during wire stringing operations.

6. Communication conductors on unguyed supports at railroad and limited access highway crossings

The longitudinal load shall be assumed equal to an unbalanced pull in the direction of the crossing of all open-wire conductors supported, where the tension of each conductor is assumed to be 50% of its rated breaking strength in the heavy-loading district, 33-1/3% in the medium-loading district, and 22-1/4% in the light-loading district.

RECOMMENDATION: Structures having a longitudinal strength capability should be provided at reasonable intervals along the line.

D. Simultaneous application of loads

Where a combination of vertical, transverse, or longitudinal loads may occur simultaneously, the structure shall be designed to withstand the simultaneous application of these loads.

NOTE: Under the extreme wind conditions of Rule 250C, an oblique wind may require greater structural strength than that computed by Rules 252B and 252C.

253. Load factors for structures, crossarms, support hardware, guys, foundations, and anchors

Loads due to the district loads in Rule 250B, the extreme wind loading condition in Rule 250C, and the extreme ice with concurrent wind condition in Rule 250D shall be multiplied by the load factors in Table 253-1.

Table 253-1—Load factors for structures[1], crossarms, support hardware[8], guys, foundations, and anchors to be used with the strength factors of Table 261-1

Load Factors			
	Grade B	Grade C	
		At crossings[6]	Elsewhere
Rule 250B loads (Combined ice and wind district loading) Vertical loads[3]	1.50	1.90[5]	1.90[5]
Transverse loads Wind Wire tension	 2.50 1.65[2]	 2.20 1.30[4]	 1.75 1.30[4]
Longitudinal loads In general At deadends	 1.10 1.65[2]	 No requirement 1.30[4]	 No requirement 1.30[4]
Rule 250C loads (Extreme wind) Wind loads All other loads	 1.00 1.00	 0.87[7] 1.00	 0.87[7] 1.00
Rule 250D loads (Extreme ice with concurrent wind)	1.00	1.00	1.00

[1]Includes pole.
[2]For guys and anchors associated with structures supporting communication conductors and cables only, this factor may be reduced to 1.33.
[3]Where vertical loads significantly reduce the stress in a structure member, a vertical load factor of 1.0 should be used for the design of such member. Such member shall be designed for the worst case loading.
[4]For metal or prestressed concrete, portions of structures, crossarms, guys, foundations, and anchors, use a value of 1.10.
[5]For metal, prestressed concrete, or fiber-reinforced polymer portions of structures and crossarms, guys, foundations, and anchors, use a value of 1.50.
[6]This applies only where a line crosses another supply or communication line (see Rule 241C and Table 242-1).
[7]For wind velocities above 100 mph (except Alaska), a factor of 0.75 may be used.
[8]Support hardware does not include insulators. See Section 27 for insulator strength and loading requirements.

Section 26.
Strength requirements

260. General (see also Section 20)

A. Preliminary assumptions

1. It is recognized that deformation, deflections, or displacement of parts of the structure may change the effects of the loads assumed. In the calculation of stresses, allowance may be made for such deformation, deflection, or displacement of supporting structures including poles, towers, guys, crossarms, pins, conductor fastenings, and insulators when the effects can be evaluated. Such deformation, deflection, or displacement should be calculated using Rule 250 loads prior to application of the load factors in Rule 253. For crossings or conflicts, the calculations shall be subject to mutual agreement.

   NOTE: Depending upon the characteristics of the structural material, significant sustained (everyday) stress (such as stresses produced by gravity or tension loads) can decrease the strength during the expected life of the material and may require guying or bracing to be able to meet the required strength capability.

2. It is recognized that new materials may become available. While these materials are in the process of development, they must be tested and evaluated. Trial installations are permitted where the requirements of Rule 13A2 are met.

B. Application of strength factors

1. Supporting structures and structural components shall be designed to withstand the appropriate loads multiplied by the load factors in Section 25 without exceeding their strength multiplied by the strength factors in Table 261-1.

   EXCEPTION: For insulators, see Section 27 for strength and loading requirements.

   NOTE 1: The latest edition of the following document may be used for providing information for determining the 5% lower exclusion limit strength of a FRP structure or component for use with an appropriate strength factor (Table 261-1) and the specified NESC loads and load factors (Table 253-1): ASCE-111, Reliability-Based Design of Utility Pole Structures [B18].

   NOTE 2: The latest edition (unless a specific edition is referenced) of the following documents are among those available for determining structure design capacity with the specified NESC loads, load factors, and strength factors:

   ANSI/ASCE-10, Design of Latticed Steel Transmission Structures [B12]
   ASCE-91, Design of Guyed Electrical Transmission Structure [B16]
   ASCE-123, Prestressed Concrete Transmission Pole Structures Recommended Practice for Design and Installation [B20]
   ASCE-48, Design of Steel Transmission Pole Structures [B15]
   ASCE-104, Recommended Practice For Fiber-Reinforced Polymer Products For Overhead Utility Line Structures [B17]
   PCI Design Handbook: Precast and Prestressed Concrete [B71]
   ASCE-113, Substation Structure Design Guide [B19]
   ACI-318, Building Code Requirements for Structural Concrete (for reinforced concrete designs) [B3]
   ACI-318, 1983, Building Code Requirements for Structural Concrete (for anchor bolt bond strength and design) [B4]
   IEEE Std 751™-1991, IEEE Trial-Use Design Guide for Wood Transmission Structures [B38]
   AISI S100, Specification for the Design of Cold-Formed Steel Structural Members [B5]
   The Aluminum Association, Aluminum Design Manual [B72]
   U.S. Dept. of Agriculture Rural Utilities Service Utility Electric Program Bulletin 1724E-200 Design Manual for High Voltage Transmission Lines.

2. Where strength factors are not defined in Rule 261, a strength factor of 0.80 shall be used for the extreme wind loading conditions specified in Rule 250C and for the extreme ice with concurrent wind specified in Rule 250D for all supported facilities.

261. Grades B and C construction

A. Supporting structures

The strength requirements for supporting structures may be met by the structures alone or with the aid of guys or braces or both.

1. Metal, prestressed-, and reinforced-concrete structures

a. These structures shall be designed to withstand the loads in Rule 252 multiplied by the appropriate load factors in Table 253-1 without exceeding the permitted stress.

NOTE: When determining required strength for axial loads, buckling needs to be considered.

b. The permitted stress shall be the strength multiplied by the strength factors in Table 261-1 (where guys are used, see Rule 261C).

c. All structures including those below 18 m (60 ft) shall be designed to withstand, without conductors, the extreme wind load in Rule 250C applied in any direction on the structure and any supported facilities and equipment that may be in place prior to installation of conductors.

d. Spliced and reinforced structures

Reinforcements or permanent splices to a supporting structure are permitted provided they develop the required strength of the structure.

2. Wood structures

Wood structures shall be of material and dimensions to meet the following requirements:

a. Wood structures shall be designed to withstand the loads in Rule 252 multiplied by the appropriate load factors in Table 253-1 without exceeding the permitted stress level at the point of maximum stress.

EXCEPTION 1: When installed, unguyed naturally grown wood poles 16.8 m (55 ft) or less in total length, acting as single-based structures or unbraced multiple-pole structures, shall meet the requirements of Rule 261A2a without exceeding the permitted stress level at the ground line. However, all guyed poles, regardless of length, shall meet the requirements of Rule 261A2a without exceeding the permitted stress level at points of attachment for guys and guy struts.

EXCEPTION 2: At a Grade B crossing, in a straight section of line, wood structures complying with the transverse strength requirements of Rule 261A2a, without the use of transverse guys, shall be considered as having the required longitudinal strength, providing the longitudinal strength is comparable to the transverse strength of the structure. This *EXCEPTION* does not modify the requirements of this rule for deadends.

EXCEPTION 3: At a Grade B crossing of a supply line over a highway or a communication line where there is an angle in the supply line, wood structures shall be considered as having the required longitudinal strength if all of the following conditions are met:

(a) The angle is not over 20 degrees.

(b) The angle structure is guyed in the plane of the resultant of the conductor tensions. The tension in this guy under the loading in Rule 252 multiplied by a load factor of 2.0 shall not exceed the rated breaking strength multiplied by the strength factor in Table 261-1.

(c) The angle structure has sufficient strength to withstand, without guys, the transverse loading of Rule 252 multiplied by the appropriate load factors in Table 253-1 or 253-2, which would exist if there were no angle at that structure without exceeding the permitted stress level.

NOTE: When determining required strength for axial loads, buckling needs to be considered.

b. Permitted stress level

(1) Natural wood pole

The permitted stress level of natural wood poles of various species meeting the requirements of ANSI O5.1-2015 shall be determined by multiplying the designated fiber strength set forth in that standard by the appropriate strength factors in Table 261-1.

(2) Sawn or laminated wood structural members, crossarms, and braces

The permitted stress level of sawn or laminated wood structural members, crossarms, and braces meeting the requirements of ANSI O5.2-2012 or ANSI O5.3-2015 shall be determined by multiplying the appropriate designated fiber strength set forth in the respective standard, by the appropriate strength factors in Table 261-1.

c. Strength of guyed poles

Guyed poles shall be designed as columns, resisting the vertical component of the tension in the guy plus any other vertical loads.

d. Spliced and reinforced poles

Reinforcements or permanent splices at any section along the pole are permitted provided they develop the required strength of the pole.

e. All structures including those below 18 m (60 ft) shall be designed to withstand, without conductors, the extreme wind load in Rule 250C applied in any direction on the structure and any supported facilities and equipment which may be in place prior to installation of conductors.

3. Fiber-reinforced polymer structures

a. These structures shall be designed to withstand the loads in Rule 252 multiplied by the appropriate load factors in Table 253-1 without exceeding the permitted load.

NOTE: When determining required strength for axial loads, buckling needs to be considered.

b. The permitted load shall be the 5th percentile strength (i.e., "5% lower exclusion limit") or less, multiplied by the strength factors in Table 261-1 (where guys are used, see Rule 261C).

c. Spliced and reinforced poles

Reinforcements or permanent splices to a supporting pole are permitted provided they develop the required strength of the pole.

d. All structures including those below 18 m (60 ft) shall be designed to withstand, without conductors, the extreme wind load in Rule 250C applied in any direction on the structure and any supported facilities and equipment which may be in place prior to installation of conductors.

4. Transverse strength requirements for structures where side guying is required, but can be installed only at a distance

Grade B: If the transverse strength requirements of this section cannot be met except by the use of side guys or special structures, and where it is physically impractical to employ side guys, the transverse strength requirements may be met by side-guying the line at each side of, and as near as practical to, the crossing, or other transversely weak structure, and with a distance between such side-guyed structures of not over 250 m (800 ft), provided that:

a. The side-guyed structures for each such section of 250 m (800 ft) or less shall be designed to withstand the calculated transverse load due to wind on the supports and ice-covered conductors, on the entire section between side-guyed structures.

b. The line between such side-guyed structures shall be substantially in a straight line and the average span between the side-guyed structures shall not exceed 45 m (150 ft).

c. The entire section between the structures with the required transverse strength shall comply with the highest grade of construction concerned in the given section, except as to the transverse strength of the intermediate poles or towers.

Grade C: The above provisions do not apply to Grade C.

5. Longitudinal strength requirements for sections of higher grade in lines of a lower grade construction

a. Methods of providing longitudinal strength

Grade B: The longitudinal strength requirements for sections of line of higher grade in lines of a lower grade (for assumed longitudinal loading, see Rule 252) may be met by placing a structure of the required longitudinal strength at each end of the higher grade section.

Where this is impractical, the structures of the required longitudinal strength may be located away from the section of higher grade, within 150 m (500 ft) on each side and with not more than 250 m (800 ft) between the structures of the required longitudinal strength. This is permitted provided the following conditions are met:

(1) The structures and the line between them meet the requirements for transverse strength and stringing of conductors of the highest grade occurring in the section, and

(2) The line between the structures of the required longitudinal strength is approximately straight or suitably guyed.

The longitudinal strength requirement of the structures may be met by using guys.

Grade C: The above provisions do not apply to Grade C.

b. Flexible supports

Grade B: When supports of the section of higher grade are capable of considerable deflection in the direction of the line, it may be necessary to increase the clearances required in Section 23 or to provide line guys or special reinforcements to reduce the deflection.

Grade C: The above provision does not apply to Grade C.

B. Strength of foundations, settings, and guy anchors

Foundations, settings, and guy anchors shall be designed or be determined by experience to withstand the loads in Rule 252 multiplied by the load factors in Table 253-1 without exceeding the permitted load. The permitted load shall be equal to the strength multiplied by the strength factors in Table 261-1.

NOTE 1: Excessive movement of foundations, settings, and guy anchors or errors in settings can reduce clearances or structure capacity.

NOTE 2: Soil saturation can have an adverse effect on the strengths of foundations, settings, and guy anchors.

C. Strength of guys and guy insulators

The strength requirements for guys and guy insulators are covered under Rules 264 and 279A1c, respectively.

1. Metal and prestressed-concrete structures

Guys shall be considered as an integral part of the structure.

2. Wood and reinforced-concrete structures

When guys are used to meet the strength requirements, they shall be considered as taking the entire load in the direction in which they act, the structure acting as a strut only, except for those structures considered to possess sufficient rigidity so that the guy can be considered an integral part of the structure.

NOTE: Excessive movement of guys can reduce clearances or structure capacity.

3. Fiber-reinforced polymer structures

When guys are used to meet the strength requirements, the guys shall be considered as taking the entire load in the direction in which they act, as if the structure is acting as a strut only, except for those structures considered to possess sufficient rigidity so that the guys can be considered an integral part of the structure.

NOTE: Excessive movement of guys can reduce clearances or structure capacity.

D. Crossarms and braces

1. Concrete and metal crossarms and braces

Crossarms and braces shall be designed to withstand the loads in Rule 252 multiplied by the load factors in Table 253-1 without exceeding the permitted load. The permitted load shall be equal to the strength multiplied by the strength factors in Table 261-1.

2. Wood crossarms and braces

a. Strength

(1) Crossarms and braces shall be designed to withstand the loads in Rule 252 multiplied by the load factors in Table 253-1 without exceeding their permitted stress.

(2) The permitted stress level of solid sawn or laminated wood crossarms and braces shall be determined by multiplying their ultimate fiber strength by the strength factors in Table 261-1.

b. Material and size

Wood crossarms and braces of select Southern pine or Douglas fir shall have a cross section of not less than those in Table 261-2. Crossarms of other species may be used provided they have equal strength.

3. Fiber-reinforced polymer crossarms and braces

Crossarms and braces shall be designed to withstand the loads in Rule 252 multiplied by the load factors in Table 253-1 without exceeding the permitted load. The permitted load shall be the 5th percentile strength (i.e., "5% lower exclusion limit") or less, multiplied by the strength factors in Table 261-1.

4. Crossarms and braces of other materials

Crossarms and braces should meet the strength requirements of Rule 261D2.

5. Additional requirements

a. Longitudinal strength

(1) General

(a) Crossarms shall be designed to withstand a load of 3.1 kN (700 lb) applied at the outer conductor attachment point without exceeding the permitted stress level for wood crossarms or the permitted load for crossarms of other materials, as applicable.

(b) At each end of a transversely weak section, as described in Rule 261A4, the longitudinal load shall be applied in the direction of the weak section.

(2) Methods of meeting Rule 261D2a(1)

Grade B: Where conductor tensions are limited to a maximum of 9.0 kN (2000 lb) per conductor, double wood crossarms having cross sections in Table 261-2 and properly assembled will comply with the longitudinal strength requirements in Rule 261D2a(1).

Grade C: This requirement is not applicable.

(3) Location

At crossings, crossarms should be mounted on the face of a pole away from the crossing, unless special bracing or double crossarms are used.

b. Bracing

Crossarms shall be supported by bracing, if necessary, to support expected loads, including line personnel working on them. Crossarm braces used only to sustain unbalanced vertical loads need only to be designed for these unbalanced vertical loads.

c. Double crossarms, brackets, or equivalent support assembly

Grade B: Where pin-type construction is used, double wood crossarms, each crossarm having the strength required by Rule 261D2a, or a support assembly equivalent in strength to double wood crossarms shall be used at each crossing structure, at ends of joint-use or conflict sections, at deadends, and at corners where the angle of departure from a straight line exceeds 20 degrees. Under similar conditions, where a bracket supports a conductor operated at more than 750 V to ground and there is no crossarm below, double brackets or a support assembly equivalent in strength to double wood crossarms shall be used.

EXCEPTION: The above does not apply where communication cables or conductors cross below supply conductors and either are attached to the same pole, or where supply conductors are continuous and of uniform tension in the crossing span and each adjacent span. This *EXCEPTION* does not apply to railroad crossings and limited access highways except by mutual agreement.

Grade C: The above requirement is not applicable.

E. Insulators

The strength requirements for insulators are covered under Rules 277 and 279.

F. Strength of pin-type or similar construction and conductor fastenings

1. Longitudinal strength

a. General

Pin-type or similar construction and ties or other conductor fastenings shall be designed to withstand the applicable longitudinal loads in Rule 252, multiplied by the load factors for longitudinal loads in Table 253-1, or 3.1 kN (700 lb) applied at the pin, whichever is greater.

b. Method of meeting Rule 261F1a

Grade B: Where conductor tensions are limited to 9.0 kN (2000 lb) and such conductors are supported on pin insulators, double wood pins and ties or their equivalent will be considered to meet the requirements of Rule 261F1a.

Grade C: No requirement.

c. At deadends and at ends of higher grade construction in line of lower grade

Grade B: Pins and ties or other conductor fastenings connected to the structure at a deadend or at each end of the higher grade section shall be designed to withstand an unbalanced pull due to the conductor load in Rule 251 multiplied by the load factors in Rule 253-1.

Grade C: This requirement is not applicable except for deadends.

d. At ends of transverse sections described in Rule 261A4

Grade B: Pins and ties or other conductor fastenings connected to the structure at ends of the transverse section as described in Rule 261A4 shall be designed to withstand the unbalanced pull in the direction of that transverse section under the load in Rule 252 multiplied by the load factors in Rule 253-1.

Grade C: No requirement.

2. Double pins and conductor fastenings

Grade B: Double pins and conductor fastenings shall be used where double crossarms or brackets are required by Rule 261D5c.

EXCEPTION: The above does not apply where communication cables or conductors cross below supply conductors and either are attached to the same pole, or where supply conductors are continuous and of uniform tension in a crossing span and each adjacent span. This *EXCEPTION* does not apply in the case of railroad crossings and limited access highway crossings except by mutual agreement.

Grade C: No requirement.

3. Single supports used in lieu of double wood pins

A single conductor support and its conductor fastening, when used in lieu of double wood pins, shall develop strength equivalent to double wood pins and their conductor fastenings as specified in Rule 261F1a.

G. Armless construction

1. General

Open conductor armless construction is a type of open conductor supply line construction in which conductors are individually supported at the structure without the use of crossarms.

2. Insulating material

Strength of insulating material shall meet the requirements of Section 27.

3. Other components

Strengths of other components shall meet the requirements of Rules 260 and 261.

H. Open supply conductors and overhead shield wires

1. Tensions

a. Design tensions shall be not more than

(1) 60% of their rated breaking strength for the load of Rule 250B as applied in Rule 251, multiplied by a load factor of 1.0.

(2) 80% of their rated breaking strength under the loads of Rules 250C and 250D as applied in Rule 251, multiplied by a load factor of 1.0, where applicable.

b. The potential for Aeolian vibration damage to conductors and related hardware shall be considered. Aeolian vibration mitigation shall be based on a qualified engineering study, manufacturer's recommendations, or experience from comparable installations. Consideration shall include but is not limited to: conductor material, stranding, type, size, tension, conductor attachment hardware, span length, wind exposure, and expected atmospheric loadings.

If from these considerations, mitigation actions are considered necessary, recognized vibration mitigation methods include, but are not limited to, the appropriate use of one or more of the following:

(1) vibration control devices
(2) stress-reduction devices
(3) self-damping conductors and (or) vibration resistant conductors
(4) reducing design tension limits for cold weather condition

c. If limiting tension in Rule 261H1b(4) is the only method applied to mitigate any potential Aeolian vibration damage, the tension at the applicable temperature listed in Table 251-1 shall not exceed the following percentages of the conductor's rated breaking strength:

35% at initial tension without external loading

25% at final tension without external loading

NOTE 1: Initial tension in this application is a conductor condition that exists immediately after installation. This condition exists before inelastic elongation, creep or stress relaxation occurs and before the conductor is subjected to external loads.

NOTE 2: Final tension in this application is intended to be the tension that exists after long term creep and prior to ice or wind loading.

NOTE 3: The above percentage limits may not protect the conductor or facilities from damage due to Aeolian vibration.

2. Splices, taps, dead-end fittings, and associated attachment hardware

a. Splices should be avoided in crossings and adjacent spans. If it is impractical to avoid such splices, they shall have sufficient strength to withstand the maximum tension resulting from the loads of Rule 250B in Rule 251 multiplied by a load factor of 1.65. If Rules 250C and 250D are applicable, splices shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 250C and 250D in Rule 251 multiplied by a load factor of 1.0.

b. Taps should be avoided in crossing spans but, if required, shall be of a type that will not impair the strength of the conductors to which they are attached.

c. Dead-end fittings, including the associated attachment hardware, shall have sufficient strength to withstand the maximum tension resulting from the loads of Rule 250B in Rule 251 multiplied by a load factor of 1.65. If Rules 250C and 250D are applicable, deadend fittings shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 250C and 250D in Rule 251 multiplied by a load factor of 1.0.

3. Trolley-contact conductors

In order to provide for wear, no trolley-contact conductor shall be installed of less size than AWG No. 0, if of copper, or AWG No. 4, if of silicon bronze.

I. Supply cable messengers

Messengers shall be stranded and shall not be stressed beyond 60% of their rated breaking strength under the loads of Rule 250B in Rule 251 multiplied by a load factor of 1.0. If Rules 250C and 250D are applicable, messengers shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 250C and 250D in Rule 251 multiplied by a load factor of 1.0.

NOTE: There are no strength requirements for cables supported by messengers.

J. Open-wire communication conductors

Open-wire communication conductors in Grade B or C construction shall have the tensions in Rule 261H1 for supply conductors of the same grade.

EXCEPTION: Where supply conductors are trolley-contact conductors of 0 to 750 V to ground, WG No. 12 Stl may be used for communication conductors for spans of 0 to 30 m (0 to 100 ft), and Stl WG No. 9 may be used for spans of 38 to 45 m (125 to 150 ft).

K. Communication cables and messengers

1. Communication cables

a. There are no strength requirements for communication cables supported by messengers. See Rule 261K2 for the strength requirements for messengers supporting communication cables.

b. Self-supporting cables shall not be stressed beyond the limits stated in Rule 261K2.

c. For paired metallic communication conductors, see Rule 261L.

2. Messenger

The messenger shall not be stressed beyond 60% of its rated breaking strength under the loads of Rule 250B in Rule 251 multiplied by a load factor of 1.0. If Rules 250C and 250D are applicable, messengers shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 250C and 250D in Rule 251 multiplied by a load factor of 1.0.

NOTE: The above tension limitations might exceed the maximum allowable design tensions of some self-supporting fiber-optic cables for operational reliability. Depending on the type of fiber-optic cable, the maximum allowable design tensions may be referred to as Maximum Rated Design Tension (MRDT), Maximum Rated Cable Load (MRCL), or Maximum Allowed Tension (MAT).

L. Paired metallic communication conductors

1. Paired conductors supported on messenger

a. Use of messenger

A messenger may be used for supporting paired conductors in any location, but is required for paired conductors crossing over trolley-contact conductors of more than 7.5 kV to ground.

b. Tension of messenger

Messenger used for supporting paired conductors required to meet Grade B construction because of crossing over trolley-contact conductors shall meet the tension requirements for Grade B.

c. Size and sag of conductors

There are no requirements for paired conductors when supported on messenger.

2. Paired conductors not supported on messenger

   a. Above supply lines

      Grade B: Tensions shall not exceed those in Rule 261H1 for supply conductors of similar grade.

      Grade C: Sizes and tensions

      Spans 0 to 30 m (0 to 100 ft)—No requirements.

      Each conductor shall have a rated breaking strength of not less than 0.75 kN (170 lb).

      Spans 30 m to 45 m (100 ft to 150 ft)— Tensions shall not exceed those required for Grade B communication conductors.

      Spans exceeding 45 m (150 ft)—Tensions shall not exceed those required for Grade C supply conductors. (See Rule 261H1.)

   b. Above trolley-contact conductors

      Grade B: Sizes and tensions

      Spans 0 to 30 m (0 to 100 ft)—No size requirements. Tensions shall not exceed those of Rule 261H1.

      Spans exceeding 30 m (100 ft)—Each conductor shall have a rated breaking strength of not less than 0.75 kN (170 lb). Tensions shall not exceed those of Rule 261H1.

      Grade C: Sizes and tensions

      Spans 0 to 30 m (0 to 100 ft)—No requirements.

      Spans exceeding 30 m (100 ft)—No tension requirements.

      Each conductor shall have a rated breaking strength of not less than 0.75 kN (170 lb).

M. Support and attachment hardware

The strength required for all support and attachment hardware not covered by Rule 261F or 261H2 shall be not less than the load times the appropriate load factor given in Section 25 and the load factor shall not be less than 1.0. For appropriate strength factors, see Rule 260B.

N. Climbing and working steps and their attachments to the structure

The strength required for all climbing devices (includes steps, ladders, platforms and their attachments) shall be capable of supporting 2.0 times the maximum intended load. Unless otherwise quantified by the owner, the maximum intended load shall be assumed to be 136 kg (300 lb), which includes the weight of the lineman, harness, tools, and equipment being supported by the lineman.

NOTE: See IEEE Std 1307™-2004 [B53].

Table 261-1—Strength factors for structures①, crossarms, braces, support hardware, guys, foundations, and anchors

[It is recognized that structures will experience some level of deterioration after installation, depending upon materials, maintenance, and service conditions. The table values specify strengths required at installation. Footnotes specify deterioration allowed, if any. When new or changed facilities add loads to existing structures (a) the strength of the structure when new shall have been great enough to support the additional loads and (b) the strength of the deteriorated structure shall exceed the strength required at replacement. If either (a) or (b) cannot be met, the structure must be replaced, augmented, or rehabilitated.]

	Grade B	Grade C
Strength factors for use with loads of Rule 250B (combined ice and wind district loading)		
Metal and prestressed-concrete structures, crossarms, and braces ⑥	1.0	1.0
Wood and reinforced-concrete structures, crossarms, and braces ② ④	0.65	0.85
Fiber-reinforced polymer structures, crossarms, and braces ⑥	1.0	1.0
Support hardware	1.0	1.0
Guy wire ⑤ ⑥	0.9	0.9
Guy anchor and foundation ⑥	1.0	1.0
Strength factors for use with loads of Rules 250C (extreme wind) and 250D (extreme ice with concurrent wind loadings)		
Metal and prestressed-concrete structures, crossarms, and braces ⑥	1.0	1.0
Wood and reinforced-concrete structures, crossarms, and braces ③ ④	0.75	0.75
Fiber-reinforced polymer structures, crossarms, and braces ⑥	1.0	1.0
Support hardware	0.8	0.8
Guy wire ⑤ ⑥	0.9	0.9
Guy anchor and foundation ⑥	1.0	1.0

①Includes poles.

②Wood and reinforced structures shall be replaced or rehabilitated when deterioration reduces the structure strength to 2/3 of that required when installed. When new or changed facilities modify loads on existing structures, the required strength shall be based on the revised loadings. If a structure or component is replaced, it shall meet the strength required by Table 261-1. If a structure or component is rehabilitated, the rehabilitated portions of the structures shall have strength greater than 2/3 of that required when installed.

③Wood and reinforced structures shall be replaced or rehabilitated when deterioration reduces the structure strength to 3/4 of that required when installed. When new or changed facilities modify loads on existing structures, the required strength shall be based on the revised loadings. If a structure or component is replaced, it shall meet the strength required by Table 261-1. If a structure or component is rehabilitated, the rehabilitated portions of the structures shall have strength greater than 3/4 of that required when installed.

④Where a wood or reinforced concrete structure is built for temporary service, the structure strength may be reduced to values as low as those permitted by Footnotes 2 and 3 provided the structure strength does not decrease below the minimum required during the planned life of the structure.

⑤For guy insulator requirements, see Rule 279.

⑥Deterioration during service shall not reduce strength capability below the required strength.

Table 261-2—Dimensions of crossarm cross section of select Southern Pine and Douglas Fir

Crossarm length		Grades of construction	
		Grade B	Grade C
1.20 m or less	mm:	75 × 100	70 × 95
4 ft or less	in:	3 × 4	2-3/4 × 3-3/4
2.45 m	mm:	82 × 108	75 × 100
8 ft	in:	3-1/4 × 4-1/4	3 × 4
3.0 m	mm:	82 × 108	75 × 100
10 ft	in:	3-1/4 × 4-1/4	3 × 4

262. Number 262 not used in this edition.

263. Grade N construction

The strength of Grade N construction need not be equal to or greater than Grade C.

A. Poles

Poles used for lines for which neither Grade B nor C is required shall be of initial size or guyed or braced to withstand expected loads, including line personnel working on them.

B. Guys

The general requirements for guys are covered in Rules 264 and 279A.

C. Crossarm strength

Crossarms shall be securely supported by bracing, if necessary, to withstand expected loads, including line personnel working on them.

NOTE: Double crossarms are generally used at crossings, unbalanced corners, and dead ends, in order to permit conductor fastenings at two insulators to limit the opportunity for slipping, although single crossarms might provide sufficient strength. To secure extra strength, double crossarms are frequently used, and crossarm guys are sometimes used.

D. Supply line conductors

1. Size

Supply-line conductors shall be not smaller than the sizes listed in Table 263-1.

RECOMMENDATION: It is recommended that these sizes for copper and steel not be used in spans longer than 45 m (150 ft) for the heavy-loading district, and 53 m (175 ft) for the medium- and light-loading districts.

E. Service drops

1. Size of open-wire service drops

a. Not over 750 V.

Service drops shall be as required by (1) or (2):

(1) Spans not exceeding 45 m (150 ft)

Sizes shall be not smaller than those in Table 263-2.

(2) Spans exceeding 45 m (150 ft)

Sizes shall be not smaller than 8 AWG.

b. Exceeding 750 V

Sizes of service drops of more than 750 V shall be not less than required for supply line conductors of the same voltage.

2. Tension of open-wire service drops

The tension of the service drop conductors shall not exceed the strength of the conductor attachment or its support under the expected loads.

3. Cabled service drops

Service conductors may be grouped together in a cable, provided the following requirements are met:

a. Size

The size of each conductor shall be not less than required for drops of separate conductors (Rule 263E1).

b. Tension of cabled service drops

The tension of the service drop conductors shall not exceed the strength of the conductor attachment or its support under the expected loads.

F. Trolley-contact conductors

In order to provide for wear, trolley-contact conductors shall be not smaller than size AWG No. 0, if of copper, or AWG No. 4, if of silicon bronze.

G. Communication conductors

There are no specific requirements for Grade N communication line conductors or service drops.

H. Street and area lighting equipment

The lowering rope or chain for luminaires arranged to be lowered for examination or maintenance shall be of a material and strength designed to withstand climatic conditions and to sustain the luminaire safely.

I. Insulators

The strength requirements for insulators are covered under Rules 277 and 279.

Table 263-1—Sizes for Grade N supply line conductors

	Required AWG ① or Stl WG ②
Soft copper	6
Medium- or hard-drawn copper	8
Steel	9
Stranded aluminum:	
EC	2
ACSR	4
ALLOY	4
ACAR	2

①Copper or aluminum
②Steel

Table 263-2—Sizes of service drops of 750 V or less
(Voltages of trolley-contact conductors are voltage to ground.
AWG used for aluminum and copper wires; Stl WG used for steel wire.)

	Copper wire			
Situation	**Soft-drawn**	**Medium- or hard-drawn**	**Steel wire**	**EC aluminum wire ②**
Alone	10	12	12	4
Concerned with communication conductor	10	12	12	4
Over supply conductors of				
0 to 750 V	10	12	12	4
750 V to 8.7 kV ①	8	10	12	4
Exceeding 8.7 kV ①	6	8	9	4
Over trolley-contact conductors				
0 to 750 V ac or dc	8	10	12	4
Exceeding 750 V ac or dc	6	8	9	4

①Installation of service drops of not more than 750 V above supply lines of more than 750 V should be avoided where practical.
②ACSR or high-strength aluminum alloy conductor size shall be not less than No. 6.

264. Guying and bracing

A. Where used

When the loads are greater than can be supported by the structure alone, additional strength shall be provided by the use of guys, braces, or other suitable construction. Such measures shall also be used where necessary to limit the increase of sags in adjacent spans and provide sufficient strength for those supports on which the loads are sufficiently unbalanced, for example, at corners, angles, dead ends, large differences in span lengths, and changes of grade of construction.

B. Strength

Guys shall be designed to withstand the loads in Rule 252 multiplied by the load factors in Table 253-1 without exceeding the permitted load. The permitted load shall be equal to the strength multiplied by the strength factors in Table 261-1. For guy wires conforming to ASTM standards, the nominal breaking strength value therein defined shall be the rated breaking strength required in this Code.

NOTE: For protection and marking of guys, see Rule 217C.

C. Point of attachment

The guy or brace should be attached to the structure as near as is practical to the center of the conductor load to be sustained. However, on lines exceeding 8.7 kV, the location of the guy or brace may be adjusted to minimize the reduction of the insulation offered by nonmetallic support arms and supporting structures.

D. Guy fastenings

Guys having a rated breaking strength of 9.0 kN (2000 lb) or more and that are subject to small radius bends should be stranded and should be protected by suitable guy thimbles or their equivalent. Any guy having a design loading of 44.5 kN (10 000 lb) or more wrapped around cedar or similar softwood poles should be protected by the use of suitable guy shims.

Where there is a tendency for the guy to slip off the shim, guy hooks or other suitable means of limiting the likelihood of this action should be used. Shims are not necessary in the case of supplementary guys, such as storm guys.

E. Electrolysis

Where anchors and rods are subject to electrolysis, suitable measures should be taken to minimize corrosion from this source.

F. Anchor rods

1. Anchor rods should be installed so as to be in line with the pull of the attached guy when under load.

   EXCEPTION: This is not required for anchor rods installed in rock or concrete.

2. The anchor and rod assembly shall have an ultimate strength not less than that required of the guy(s) by Rule 264B.

Section 27. Line insulation

270. Application of rule

These requirements apply only to open-conductor supply lines.

NOTE 1: See Rule 243C4.

NOTE 2: See Rule 242E for insulation requirements for neutral conductors.

271. Material and marking

Insulators for operation of supply circuits shall be manufactured and marked in accordance with the C29 series of American National Standards.

EXCEPTION: Other materials and criteria may be used if they provide electrical and mechanical performance and identification appropriate for the application.

272. Ratio of flashover to puncture voltage

Insulators for which the shortest puncture path through the insulator is less than half the dry arcing distance of the insulator shall be designed so that the ratio of their rated low-frequency dry-flashover voltage to low-frequency puncture voltage is in conformance with applicable American National Standards. When a standard does not exist, this ratio shall not exceed 75%.

The applicable American National Standards are as follows:

ANSI C29.1-1988 (R2012)

ANSI C29.2 (superseded)

ANSI C29.2A-2013

ANSI C29.2B-2013

ANSI C29.5-2012

ANSI C29.6-2012

ANSI C29.8-2012

EXCEPTION: Insulators specifically designed for use in areas of high atmospheric contamination may have a rated low-frequency dry-flashover voltage not more than 80% of their low-frequency puncture voltage.

273. Insulation level

The rated dry flashover voltage of the insulator or insulators, when tested in accordance with ANSI C29.1-1988 (R2012), shall be not less than that shown in Table 273-1, unless based on a qualified engineering study. Higher insulation levels than those shown in Table 273-1, or other effective means, shall be used where severe lightning, high atmospheric contamination, or other unfavorable conditions exist. Insulation levels for system voltages in excess of those shown shall be based on a qualified engineering study.

Table 273-1—Insulation level requirements

Nominal voltage (between phases) (kV)	Rated dry flashover voltage of insulators ① (kV)	Nominal voltage (between phases) (kV)	Rated dry flashover voltage of insulators ① (kV)
0.75	5	115	315
2.4	20	138	390
6.9	39	161	445
13.2	55	230	640
23.0	75	345	830
34.5	100	500	965
46	125	765	1145
69	175		

①Interpolate for intermediate values.

274. Factory tests

Each insulator or insulating part thereof for use on circuits operating at or above 2.3 kV between conductors shall be tested by the manufacturer in accordance with applicable American National Standards, or, where such standards do not exist, other good engineering practices to ensure their performance.

EXCEPTION: Where guy insulators are manufactured per designs for which validation tests have been performed as specified in Rule 279A1b and a valid quality assurance program is followed, this rule does not require that dry and wet flashover tests be performed on each guy insulator unit.

The applicable American National Standards are listed in Rule 272.

275. Special insulator applications

A. Insulators for constant-current circuits

Insulators for use on constant-current circuits shall be selected on the basis of the rated full-load voltage of the supply transformer.

B. Insulators for single-phase circuits directly connected to three-phase circuits

Insulators used on single-phase circuits directly connected to three-phase circuits (without intervening isolating transformers) shall have an insulation level not less than that required for the three-phase circuit.

276. Number 276 not used in this edition.

277. Mechanical strength of insulators

Insulators shall withstand all applicable loads specified in Rules 250, 251, and 252 without exceeding the percentages of their strength rating for the respective insulator type shown in Table 277-1.

EXCEPTION: Strength rating percentages other than those in Table 277-1 may be used if supported by a qualified engineering study, operating experience for local conditions, or recommendations of manufacturers.

Table 277-1—Allowed percentages of strength ratings

Insulator type	Permitted stress[5] (allowed percentage of strength ratings)		Strength or load rating[1]	Reference standard
	Loading from Rule 250B	Loadings from Rules 250C and 250D		
Ceramic and toughened glass				
Suspension type[2] Distribution class 108 mm to 203 mm (4.25 in to 8 in) in diameter	50%	50%	Combined mechanical and electrical strength	ANSI C29.2A-2013
Suspension type[2] Transmission class 228.6 mm (9 in) and larger in diameter	50%	50%[6]	Combined mechanical and electrical strength	ANSI C29.2 (superseded) (1.2 standard deviation M&E)
	50%	65%[6]	Combined mechanical and electrical strength	ANSI C29.2B-2013 (3.0 standard deviation M&E)
Line post	40%	40%	Cantilever strength	ANSI C29.7-2012
	50%	50%	Tension, compression strength	
Station post	40%	40%	Cantilever strength	ANSI C29.9-2012
	50%	50%	Tension, compression, or torsion strength	
Station cap and pin	40%	40%	Cantilever, tension, compression, or torsion strength	ANSI C29.8-2012
Pin	40%	40%	Cantilever strength	ANSI C29.5-2012 and ANSI C29.6-2012
Spool	50%	50%	Transverse strength	ANSI C29.3-2012

Table 277-1—Allowed percentages of strength ratings *(continued)*

Insulator type	Permitted stress[5] (allowed percentage of strength ratings)		Strength or load rating[1]	Reference standard
	Loading from Rule 250B	Loadings from Rules 250C and 250D		
Nonceramic				
Suspension type[2] Transmission class	50%	65%	Specified mechanical load (SML)	ANSI C29.12-2012
Suspension type[2] Distribution class	50%	65%	Specified mechanical load (SML)	ANSI C29.13-2013
Line post Transmission class	50%	50%	Specified cantilever load (SCL)	ANSI C29.17-2002
	50%	50%	Specified tensile load (STL)	
Line post Distribution class	50%	50%	Specified cantilever load (SCL)	ANSI C29.18-2013
	50%	50%	Specified tensile load (STL)	
Station post	See Footnote 3.	See Footnote 3.	All strength ratings	See Footnote 4.
Pin	See Footnote 3.	See Footnote 3	Cantilever strength	See Footnote 4.
Spool	See Footnote 3.	See Footnote 3	Transverse strength	See Footnote 4.

①All strengths shall be supplied by the respective manufacturers.
②Suspension type includes deadend applications.
③This percentage shall be supplied by the manufacturer.
④Industry standards do not currently exist.
⑤Permitted stress for insulators meeting requirements specified in the given edition of reference standards and for exceptional loading conditions. Permitted stress for insulators meeting earlier editions of the standards and for long-term everyday loading should not exceed the proof-test load specified in the appropriate standards.
⑥The 50% factor applies to porcelain and toughened glass insulators manufactured to the 1.2 Standard Deviation criterion in earlier versions of ANSI C29.2. For insulators manufactured to ANSI C29.2B-2013 or otherwise to a Standard Deviation criterion of at least 3, a 65% factor can be applied.

278. Aerial cable systems

A. Electrical requirements

1. Covered or insulated conductors not meeting the requirements of Rule 230C1, 230C2, or 230C3 shall be considered as bare conductors for all insulation requirements.
2. The insulators or insulating supports shall meet the requirements of Rule 273.
3. The systems shall be so designed and installed as to minimize long-term deterioration from electrical stress.

B. Mechanical requirements

1. Insulators other than spacers used to support aerial cable systems shall meet the requirements of Rule 277.

2. Insulating spacers used in spacer cable systems shall withstand the loads specified in Section 25 (except those of Rules 250C and 250D) without exceeding 50% of their rated ultimate strength.

279. Guy and span insulators

A. Insulators

1. Properties of guy insulators

Where guy insulators are used in accordance with Rule 215C2, the guy insulators shall meet the following requirements:

a. Material

Insulators shall be made of wet-process porcelain, wood, fiber-reinforced polymer, or other material of suitable mechanical and electrical properties.

b. Electrical strength

A guy insulator may consist of one or more units. The guy insulator design shall have a rated dry flashover voltage at least double, and a rated wet flashover voltage at least as high as, the voltage to which the insulator may be exposed with guys intact or under the conditions of Rule 215C2. Testing shall validate dry and wet flashover values using the Low-Frequency Dry and Low-Frequency Wet Flashover Voltage Tests specified in ANSI C29.1-1988 (R2012) or ANSI C29.11-2012 [B6].

Fiber-reinforced polymer guy insulators, or guy insulators of other suitable materials, that can reasonably be expected to be degraded by ultraviolet light shall be protected against UV degradation.

c. Mechanical strength

The rated ultimate strength of the guy insulator shall be at least equal to the required strength of the guy in which it is installed.

2. Galvanic corrosion and BIL insulation

a. Limitation of galvanic corrosion

An insulator in the guy strand used exclusively to limit galvanic corrosion of metal in ground rods, anchors, anchor rods, or pipe in an effectively grounded system shall not be classified as a guy insulator and shall not reduce the mechanical strength of the guy.

NOTE: See Rule 215C7.

b. BIL insulation

An insulator in the guy strand used exclusively to meet BIL requirements for the structure in an effectively grounded system shall not be classified as a guy insulator, provided mechanical strength of the insulator meets Rule 279A1c and either of the following provisions is met:

(1) The guy is otherwise insulated to meet the requirements of Rules 215C2 and 279A1.

(2) Anchor guys are effectively grounded below the BIL insulator as illustrated in Figure 279-1, and span guys are effectively grounded beyond the BIL insulator in accordance with Rules 092C2 and 215C2.

B. Properties of span-wire insulators

Where span-wire insulators are used in accordance with Rule 215C3, the span-wire insulators shall meet the following requirements:

1. Material

Insulators shall be made of wet-process porcelain, wood, fiber-reinforced polymer, or other material of suitable mechanical and electrical properties.

2. Insulation level

   The insulation level of span-wire insulators shall meet the requirements of Rule 274.

   A hanger insulator, where used to provide single insulation as permitted by Rule 279B2, shall meet the requirements of Rule 274.

3. Mechanical strength

   The rated ultimate strength of the span-wire insulator shall be at least equal to the required strength of the span wire in which it is located.

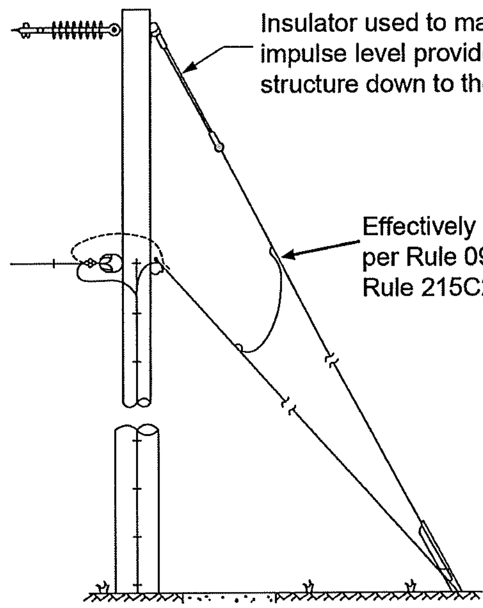


Figure 279-1—Insulator used for BIL insulation

28. Section number 28 not used in this edition.

29. Section number 29 not used in this edition.

Part 3.
Safety Rules for the Installation and Maintenance of Underground Electric Supply and Communication Lines

Section 30.
Purpose, scope, and application of rules

300. Purpose

The purpose of Part 3 of this Code is the practical safeguarding of persons during the installation, operation, or maintenance of underground or buried supply and communication cables and associated equipment.

301. Scope

Part 3 of this Code covers supply and communication cables and equipment in underground or buried systems. The rules cover the associated structural arrangements and the extension of such systems into buildings. It also covers the cables and equipment employed primarily for the utilization of electric power when such cables and equipment are used by the utility in the exercise of its function as a utility. They do not cover installations in electric supply stations.

302. Application of rules

The general requirements for application of these rules are contained in Rule 13.

While it is common practice to use the terms *duct* and *conduit* interchangeably, in Part 3 they have distinct definitions. Duct is a single enclosed raceway for conductors or cable; conduit is a structure containing one or more ducts; and conduit system is the combination of duct, conduit, conduits, manholes, handholes, and/or vaults joined to form an integrated whole.

Section 31.
General requirements applying to underground lines

310. Referenced sections

The Introduction (Section 1), Definitions (Section 2), References (Section 3), and Grounding methods (Section 9) of this Code shall apply to the requirements of Part 3.

311. Installation and maintenance

A. Persons responsible for underground facilities shall be able to indicate the location of their facilities.

B. Reasonable advance notice should be given to owners or operators of other proximate facilities that may be adversely affected by new construction or changes in existing facilities.

C. For emergency installations, supply and communication cables may be laid directly on grade if they are guarded or otherwise located so that they do not unduly obstruct pedestrian or vehicular traffic and are appropriately marked. Supply cables operating above 600 V shall meet either Rule 230C or 350B.

NOTE: See Rules 014A2 and 230A2d.

312. Accessibility

All parts that must be examined or adjusted during operation shall be arranged so as to be accessible to authorized persons by the provision of adequate working spaces, working facilities, and clearances.

313. Inspection and tests of lines and equipment

A. When in service

1. Initial compliance with safety rules

   Lines and equipment shall comply with these safety rules upon being placed in service.

2. Inspection

   Accessible lines and equipment shall be inspected by the responsible party at such intervals as experience has shown to be necessary.

3. Tests

   When considered necessary, lines and equipment shall be subjected to practical tests to determine required maintenance.

4. Inspection records

   Any conditions or defects affecting compliance with this Code revealed by inspection or tests, if not promptly corrected, shall be recorded; such records shall be maintained until the conditions or defects are corrected.

5. Corrections

   a. Lines and equipment with recorded conditions or defects that would reasonably be expected to endanger human life or property shall be promptly corrected, disconnected, or isolated.

   b. Other conditions or defects shall be designated for correction.

B. When out of service

1. Lines infrequently used

   Lines and equipment infrequently used shall be inspected or tested as necessary before being placed into service.

2. Lines temporarily out of service

   Lines and equipment temporarily out of service shall be maintained in a safe condition.

3. Lines permanently abandoned

   Lines and equipment permanently abandoned shall be removed or maintained in a safe condition.

314. Grounding of circuits and equipment

A. Methods

The methods to be used for grounding of circuits and equipment are given in Section 9.

B. Conductive parts to be grounded

Cable sheaths and shields (except conductor shields), equipment frames and cases (including pad-mounted devices), conductive lighting poles, and conductive handhole covers on non-conductive lighting poles shall be effectively grounded. Conductive-material ducts and riser guards that enclose electric supply lines or are exposed to contact with open supply conductors shall be effectively grounded.

EXCEPTION: This rule does not apply to parts that are 2.45 m (8 ft) or more above readily accessible surfaces or are otherwise isolated or guarded.

C. Circuits

1. Neutrals

   Primary neutrals, secondary and service neutrals, and common neutrals exposed to personnel contact shall be effectively grounded.

   EXCEPTION: Circuits designed for ground-fault detection and impedance current-limiting devices.

2. Other conductors

   Conductors, other than neutral conductors, that are intentionally grounded, shall be effectively grounded where exposed to personnel contact.

3. Surge arresters

   Surge arresters shall be effectively grounded.

4. Use of earth as part of circuit

   a. Supply circuits shall not be designed to use the earth normally as the sole conductor for any part of the circuit.

   b. Monopolar operation of a bipolar HVDC system is permissible for emergencies and limited periods for maintenance.

315. Communications protective requirements

A. Where required

Where communications apparatus is handled by other than qualified persons, it shall be protected by one or more of the means listed in Rule 315B if such apparatus is permanently connected to lines subject to any of the following:

1. Lightning
2. Contact with supply conductors with voltages exceeding 300 V
3. Transient rise in ground potential exceeding 300 V

4. Steady-state induced voltage of a level that may cause personal injury

   NOTE: When communication cables will be in the vicinity of supply stations where large ground currents may flow, the effect of these currents on communication circuits should be evaluated.

B. Means of protection

   Where communications apparatus is required to be protected under Rule 315A, protective means adequate to withstand the voltage expected to be impressed shall be provided by insulation, protected where necessary by surge arresters. Severe conditions may require the use of additional devices such as auxiliary arresters, drainage coils, neutralizing transformers, or isolating devices.

316. Induced voltage

Rules covering supply-line influence and communication-line susceptiveness have not been detailed in this Code. Cooperative procedures are recommended to minimize steady-state voltages induced from proximate facilities. Therefore, reasonable advance notice should be given to owners or operators of other known proximate facilities that may be adversely affected by new construction or changes in existing facilities.

Section 32.
Underground conduit systems

NOTE: For supply and communication cables installed in ducts that are not part of a conduit system, see Rule 350G.

320. Location

A. Routing

1. General

a. Conduit systems should be subject to the least disturbance practical. Conduit systems extending parallel to other subsurface structures should not be located directly over or under other subsurface structures. If this is not practical, the rule on separation, as stated in Rule 320B, should be followed.

b. Conduit alignment should be such that there are no protrusions that would be harmful to the cable.

c. Where bends are required, the bending radius shall be sufficiently large to limit the likelihood of damage to cable being installed in the conduit.

2. Natural hazards

Routes through unstable soils such as mud, shifting soil, etc., or through highly corrosive soils, should be avoided. If construction is required in these soils, the conduit should be constructed in such a manner as to minimize movement or corrosion or both.

3. Highways and streets

Where conduit must be installed longitudinally under the roadway, it should be installed in the shoulder. If this is not practical, the conduit should be installed within the limits of one lane of traffic.

4. Bridges and tunnels

The conduit system shall be located so as to limit the likelihood of damage by traffic. It should be located to provide safe access for inspection or maintenance of both the structure and the conduit system.

5. Railroad tracks

a. The top of the conduit system should be located not less than 900 mm (36 in) below the top of the rails of a street railway or 1.27 m (50 in) below the top of the rails of a railroad. Where unusual conditions exist or where proposed construction would interfere with existing installations, a greater depth than specified above may be required.

EXCEPTION: Where this is impractical, or for other reasons, this separation may be reduced by agreement between the parties concerned. In no case, however, shall the top of the conduit or any conduit protection extend higher than the bottom of the ballast section that is subject to working or cleaning.

b. Where practical, manholes, handholes, and vaults should be placed where they are not under the trackbed.

6. Water

Conduit installed under water should be routed, installed, or both so that it will be protected from erosion by tidal action or currents. The conduit should not be located where ships normally anchor.

B. Separation from other underground installations

1. General

The radial separation between a conduit system and other underground structures should be as large as necessary to permit maintenance of either the conduit system or other underground structures while limiting the likelihood of damage to the other. These separations should be determined by the parties involved.

EXCEPTION: When conduit crosses a manhole, vault, or subway tunnel roof, it may be supported directly on the roof with the concurrence of all parties involved.

2. Separations between supply and communication conduit systems

Conduit systems to be occupied by communication conductors shall be separated from conduit systems to be used for supply systems by not less than

a. 75 mm (3 in) of concrete

b. 100 mm (4 in) of masonry

c. 300 mm (12 in) of well-tamped earth

EXCEPTION: Lesser separations may be used where the parties concur.

3. Sewers, sanitary and storm

a. If conditions require a conduit to be installed parallel to and directly over a sanitary or storm sewer, it may be done provided both parties are in agreement as to the method.

b. Where a conduit run crosses a sewer, it shall be designed to have suitable support on each side of the sewer to limit the likelihood of transferring any direct load onto the sewer.

4. Water lines

Conduit should be installed as far as is practical from a water main in order to protect it from being undermined if the main breaks. Conduit that crosses over a water main shall be designed to have suitable support on each side as required to limit the likelihood of transferring any direct loads onto the main.

5. Gas and other lines that transport flammable material

Radial separation of conduit from gas and other lines that transport flammable material shall be not less than 300 mm (12 in) as measured from the nearest duct in the conduit and should have sufficient separation from gas and other lines that transport flammable material to permit the use of pipe maintenance equipment. Conduit shall not enter the same manhole, handhole, or vault with gas or other lines that transport flammable material.

EXCEPTION: For conduit containing communication cables or supply cables operating at not more than 600 V between conductors, the radial separation may be less than required by Rule 320B5 provided supplemental mechanical protection, if needed, is used to limit the likelihood of detrimental heat transfer to gas and other lines that transport flammable material due to a cable fault. Agreement to the reduced separation by all utilities involved is required.

NOTE: For appropriate separations between grounds of supply systems and pipelines used for the transmission of flammable liquids or gases operating at high pressure [1030 kPa (150 lb/in^2) or greater] see Rule 095B2.

6. Steam or cryogenic lines

Conduit should be installed with sufficient separation from steam or cryogenic lines to limit the likelihood of thermal damage to the cable. Where it is not practical to provide adequate separation, a suitable thermal barrier shall be placed between the two facilities.

321. Excavation and backfill

A. Trench

The bottom of the trench should be undisturbed, tamped, or relatively smooth earth. Where the excavation is in rock, the conduit should be laid on a protective layer of clean tamped backfill.

B. Quality of backfill

All backfill should be free of materials that may damage the conduit system. Backfill material should be adequately compacted to limit settling under the expected surface usage.

322. Conduit, ducts, and joints

A. General

1. Duct material shall be corrosion-resistant and suitable for the intended environment.
2. Duct materials, the construction of the conduit, or both shall be designed so that a cable fault in one duct would not damage the conduit to such an extent that it would cause damage to cables in adjacent ducts.
3. The conduit shall be designed to withstand external forces to which it may be subjected by the surface loadings set forth in Rule 323A, except that impact loading may be reduced one third for each 300 mm (12 in) of cover so no impact loading need be considered when cover is 900 mm (3 ft) or more.
4. The internal surface of the duct shall be free of sharp edges or burrs, which could damage supply cable.

B. Installation

1. Restraint

   Conduit, including terminations and bends, should be suitably restrained by backfill, concrete envelope, anchors, or other means to maintain its design position under stress of installation procedures, cable pulling operations, and other conditions such as settling and hydraulic or frost uplift.

2. Joints

   Ducts shall be joined in a manner so as to limit solid matter from entering the conduit line. Joints shall form a sufficiently continuous smooth interior surface between joining duct sections so that supply cable will not be damaged when pulled past the joint.

3. Externally coated pipe

   When conditions are such that externally coated pipe is required, the coating shall be corrosion resistant and should be inspected, tested, or both, to see that the coating is continuous and intact prior to backfill. Precautions shall be taken to prevent damage to the coating when backfilling.

4. Building walls, floors, or roofs

   The portion of conduit installed through an exterior building wall, floor, or roof shall have seals inside the conduit and external seals on the outside surface of the conduit at the point of entry to the building intended to limit the likelihood of the entrance of gas into the building. The use of seals may be supplemented by gas-venting devices in order to minimize building up of positive gas pressures in the conduit.

5. Bridges

   a. Conduit installed in bridges shall include the capability to allow for expansion and contraction of the bridge.
   b. Conduits passing through a bridge abutment should be installed so as to avoid or resist any shear due to soil settlement.
   c. Conduit of conductive material installed on bridges shall be effectively grounded.

6. In vicinity of manholes

   Conduit should be installed on compacted soil or otherwise supported when entering a manhole to limit the likelihood of detrimental shear stress on the conduit at the point of manhole entrance.

323. Manholes, handholes, and vaults

A. Strength

Manholes, handholes, and vaults shall be designed to sustain all expected loads that may be imposed upon the structure. The horizontal design loads, vertical design loads, or both shall consist of dead load, live load, equipment load, impact, load due to water table, frost, and any other load expected to be imposed upon the structure, to occur adjacent to the structure, or both. The structure shall sustain the combination of vertical and lateral loading that produces the maximum shear and bending moments in the structure.

1. In roadway areas, the live load shall consist of the weight of a moving tractor-semitrailer truck illustrated in Figure 323-1. The vehicle wheel load shall be considered applied to an area as indicated in Figure 323-2. In the case of multilane pavements, the structure shall sustain the combination of loadings that results in vertical and lateral structure loadings that produce the maximum shear and bending moments in the structure.

   NOTE: Loads imposed by equipment used in road construction may exceed loads to which the completed road may be subjected.

2. In designing structures not subject to vehicular loading, the design live load shall be not less than 14.5 kPa (300 lb/ft^2).
3. Live loads shall be increased by 30% for impact.
4. When hydraulic, frost, or other uplift will be encountered, the structure shall either be of sufficient weight or so restrained as to withstand this force. The weight of equipment installed in the structure is not to be considered as part of the structure weight.
5. Where pulling iron facilities are furnished, they should be installed to withstand twice the expected load to be applied to the pulling iron.

B. Dimensions

Manholes shall meet the following requirements: A clear working space sufficient for performing the necessary work shall be maintained. The horizontal dimensions of the clear working space shall be not less than 900 mm (3 ft). The vertical dimensions shall be not less than 1.83 m (6 ft) except in manholes where the opening is within 300 mm (1 ft), horizontally, of the adjacent interior side wall of the manhole.

EXCEPTION 1: Where one boundary of the working space is an unoccupied wall and the opposite boundary consists of cables only, the horizontal working space between these boundaries may be reduced to 750 mm (30 in).

EXCEPTION 2: In manholes containing only communication cables, equipment, or both, one horizontal dimension of the working space may be reduced to not less than 600 mm (2 ft), provided the other horizontal dimension is increased so that the sum of the two dimensions is at least 1.83 m (6 ft).

C. Manhole access

1. Round access openings in a manhole containing supply cables shall be not less than 650 mm (26 in) in diameter. Round access openings in any manhole containing communication cables only, or manholes containing supply cables and having a fixed ladder that does not obstruct the opening, shall be not less than 600 mm (24 in) in diameter. Rectangular access openings should have dimensions not less than 650 mm × 560 mm (26 in × 22 in).
2. Openings shall be free of protrusions that will injure personnel or prevent quick egress.

3. Manhole openings shall be located so that safe access can be provided. When in the highway, they should be located outside of the paved roadway when practical. They should be located outside the area of street intersections and crosswalks whenever practical to reduce the traffic hazards to the workers at these locations.

4. Personnel access openings should be located so that they are not directly over the cable or equipment. Where this is not practical, they can be located over the cable if one of the following is provided:

   a. A conspicuous safety sign

      NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, and ANSI Z535.4-2011 contain information regarding safety signs.

   b. A protective barrier over the cable

   c. A fixed ladder

5. Any manhole greater than 1.25 m (4 ft) in depth shall be designed so it can be entered by means of a ladder or other suitable climbing device. Equipment, cable, and hangers are not suitable climbing devices.

D. Covers

1. Manholes and handholes, when not being worked in, shall be securely closed by covers of sufficient weight or proper design so they cannot be easily removed without tools.

2. Covers should be suitably designed or restrained so that they cannot fall into manholes or protrude into manholes sufficiently far to contact cable or equipment.

3. Strength of covers and their supporting structure shall be at least sufficient to sustain the applicable loads of Rule 323A.

E. Vault and utility tunnel access

1. Access openings shall be located so that safe access can be provided.

2. Personnel access openings in vaults should be located so that they are not directly over or do not directly open into equipment or cable. In vaults, other types of openings (not personnel access) may be located over equipment to facilitate work on, replacement, or installation of equipment.

3. Where accessible to the public, access doors to utility tunnels and vaults shall be locked unless authorized person(s) are in attendance to restrict entry by unauthorized persons. Where vaults and utility tunnels contain exposed live parts, a prominent safety sign shall be posted where it is visible to persons before they enter.

   NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, and ANSI Z535.4-2011 contain information regarding safety signs.

4. Such doors shall be designed so that a person on the inside may exit when the door is locked from the outside.

   EXCEPTION: This rule does not apply where the only means of locking is by padlock and the latching system is so arranged that the padlock can be closed on the latching system to prevent locking from the outside.

5. Clearance of energized parts and controls from penetrable ventilation openings

   Where ventilation openings in an aboveground vault are not protected with louvers or baffles that limit the opportunity for penetration from outside the vault by sticks or other objects, energized parts and controls that are not guarded shall be located so as to have a clearance from the outside of the ventilation opening not less than that required by the safety clearance zone of Rule 110A2 and Table 110-1.

F. Ladder requirements

Fixed ladders shall be corrosion-resistant. Portable ladders shall be used in accordance with Rule 420J.

NOTE: ANSI ASC A14.1-2007 [B8], ANSI ASC A14.2-2007 [B9], ANSI ASC A14.3-2008 [B10], and ANSI ASC A14.5-2007 [B11] contain information about ladders.

G. Drainage

Where drainage is into sewers, suitable traps or other means should be provided to limit the likelihood of sewer gas entering into manholes, vaults, or tunnels.

H. Ventilation

Adequate ventilation to open air shall be provided for manholes, vaults, and tunnels, having an opening into enclosed areas used by the public. Where such enclosures house transformers, switches, regulators, etc., the ventilating system shall be cleaned at necessary intervals.

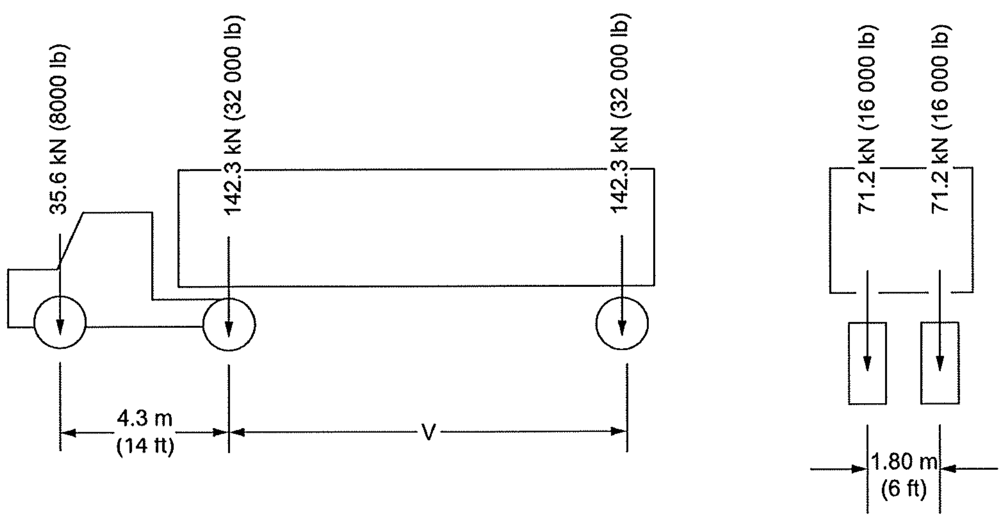
EXCEPTION: This does not apply to enclosed areas under water or in other locations where it is impractical to comply.

I. Mechanical protection

Supply cables and equipment should be installed or guarded in such a manner as to avoid damage by objects falling or being pushed through the grating.

J. Identification

Manhole and handhole covers should have an identifying mark that will indicate ownership or type of utility.



V = Variable spacing, 4.3 m to 9.0 m (14 ft to 30 ft), inclusive. Spacing to be used is that which results in vertical and lateral structure loading that produces the maximum shear and bending moments in the structure.

Figure 323-1—Roadway vehicle load

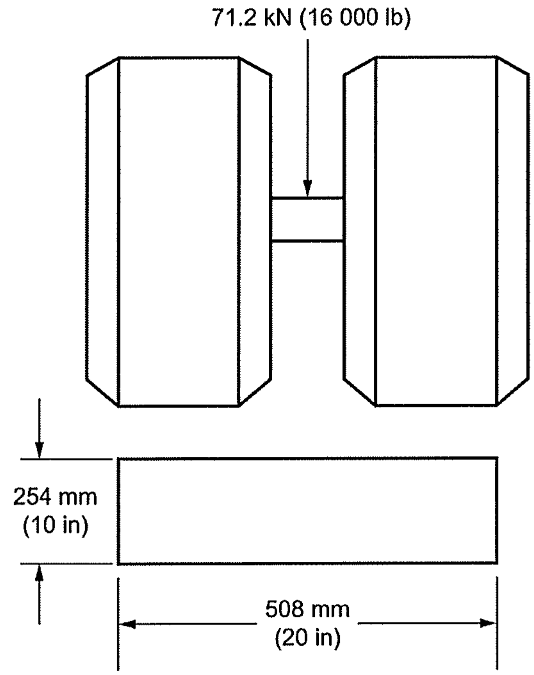


Figure 323-2—Wheel load area

Section 33.
Supply cable

330. General

A. Cable should be capable of withstanding tests applied in accordance with an applicable standard issued by a recognized organization such as the American National Standards Institute (ANSI), the Association of Edison Illuminating Companies (AEIC), the Insulated Cable Engineers Association (ICEA), the National Electrical Manufacturers Association (NEMA), or the American Society for Testing and Materials (ASTM).

B. The design and construction of conductors, insulation, sheath, jacket, and shielding shall include consideration of mechanical, thermal, environmental, and electrical stresses that are expected during installation and operation.

C. Cable shall be designed and manufactured to retain specified dimensions and structural integrity during manufacture, reeling, storage, handling, and installation.

D. Cable shall be designed and constructed in such a manner that each component is protected from harmful effects of other components.

E. The conductor, insulation, and shielding shall be designed to withstand the effects of the expected magnitude and duration of fault current, except in the immediate vicinity of the fault.

331. Sheaths and jackets

Sheaths, jackets, or both shall be provided when necessary to protect the insulation or shielding from moisture or other adverse environmental conditions.

332. Shielding

A. General

   1. Conductor shielding should, and insulation shielding shall, be provided as specified by an applicable document issued by a nationally recognized cable standardization organization.

      EXCEPTION: Shielding is not required for short jumpers that do not contact a grounded surface within enclosures or vaults, provided the jumpers are guarded or isolated.

      NOTE: Typical cable standardization organizations include: the AEIC, the ICEA, and the NEMA.

   2. Insulation shielding may be sectionalized provided that each section is effectively grounded.

B. Material

   1. The shielding system may consist of semiconducting materials, nonmagnetic metal, or both. The shielding adjacent to the insulation shall be designed to remain in intimate contact with the insulation under all operating conditions.

   2. Shielding material shall either be designed to resist excessive corrosion under the expected operating conditions or shall be protected.

333. Cable accessories and joints

A. Cable accessories and joints shall be designed to withstand the mechanical, thermal, environmental, and electrical stresses expected during operation.

B. Cable accessories and joints shall be designed and constructed in such a manner that each component of the cable and joint is protected from harmful effects of the other components.

C. Cable accessories and joints shall be designed and constructed to maintain the structural integrity of the cables to which they are applied and to withstand the magnitude and duration of the fault current expected during operation, except in the immediate vicinity of the fault.

D. For insulating joints, see Rule 332A2.

Section 34.
Cable in underground structures

340. General

A. Section 33 shall apply to supply cable in underground structures.

B. On systems operating above 2 kV to ground, the design of the conductors or cables installed in nonmetallic conduit should consider the need for an effectively grounded shield, a sheath, or both.

341. Installation

A. General

1. Bending of the supply cable during handling, installation, and operation shall be controlled to avoid damage.
2. Pulling tensions and sidewall pressures on the supply cable should be limited to avoid damage.

   NOTE: Manufacturers' recommendations may be used as a guide.
3. Ducts should be cleaned of foreign material that could damage the supply cable during pulling operations.
4. Cable lubricants shall not be detrimental to cable or conduit systems.
5. On slopes or vertical runs, consideration should be given to restraining cables to limit the likelihood of downhill movement.
6. Supply cables shall not be installed in the same duct with communication cables unless all of the cables are operated and maintained by the same utility.
7. Communication cables may be installed together in the same duct provided all utilities involved are in agreement.

B. Cable in manholes and vaults

1. Supports

   a. Cable supports shall be designed to withstand both live and static loading and should be compatible with the environment.

   b. Supports shall be provided to maintain specified clearance between cables.

   c. Horizontal runs of supply cables shall be supported at least 75 mm (3 in) above the floor, or shall be suitably protected.

   EXCEPTION: This rule does not apply to grounding or bonding conductors.

   d. The installation should allow cable movement without destructive concentration of stresses. The cable should remain on supports during operation.

   NOTE: Special protection may be necessary at the duct entrance.

2. Clearance

   a. Adequate working space shall be provided in accordance with Rule 323B.

   b. Between supply and communications facilities (cable, equipment, or both):

   (1) Where cable, equipment, or both are to be installed in a joint-use manhole or vault, it shall be done only with the concurrence of all parties concerned.

   (2) Supply and communication cables should be racked from separate walls. Crossings should be avoided.

   (3) Where supply and communication cables must be racked from the same wall, the supply cables should be racked below the communication cables.

   (4) Supply and communications facilities shall be installed to permit access to either without moving the other.

   (5) Clearances shall be not less than those specified in Table 341-1.

3. Identification

a. General

(1) Cables shall be permanently identified by tags or otherwise at each manhole or other access opening of the conduit system.

EXCEPTION: This requirement does not apply where the position of a cable, in conjunction with diagrams or maps supplied to workers, gives sufficient identification.

(2) All identification shall be of a corrosion-resistant material suitable for the environment.

(3) All identification shall be of such quality and located so as to be readable with auxiliary lighting.

b. Joint-use manholes and vaults

Cables in a manhole or vault that are operated and maintained by different utilities shall be permanently identified by markings or tags denoting the utility name and type of cable use.

Table 341-1—Clearance between supply and communications facilities in joint-use manholes and vaults

Phase-to-phase supply voltage	Surface to surface	
	(mm)	(in)
0 to 15 000	150	6
15 001 to 50 000	230	9
50 001 to 120 000	300	12
120 001 and above	600	24

EXCEPTION 1: These clearances do not apply to grounding conductors.
EXCEPTION 2: These clearances may be reduced by mutual agreement between the parties concerned when suitable barriers or guards are installed.

342. Grounding and bonding

A. Cable and joints with bare metallic shields, sheaths, or concentric neutrals that are exposed to personnel contact shall be effectively grounded.

B. Cable sheaths or shields that are connected to ground at a manhole shall be bonded or connected to a common ground.

C. Bonding and grounding leads shall be of a corrosion-resistant material suitable for the environment or suitably protected.

343. Number not used in this edition.

344. Communication cables containing special supply circuits

A. Special circuits operating at voltages in excess of 90 V ac or 150 V dc and used for supplying power solely to communications equipment may be included in communication cables under the following conditions:

1. Such cables shall have a conductive sheath or shield that shall be effectively grounded.
2. All circuits in such cables shall be owned or operated by one party and shall be maintained only by qualified personnel.
3. Supply circuits included in such cables shall be terminated at points accessible only to qualified employees.
4. Communication circuits brought out of such cables, if they do not terminate in a repeater station or terminal office, shall be protected or arranged so that in event of a failure within the cable, the voltage on the communication circuit will not exceed 400 V to ground.
5. Terminal apparatus for the power supply shall be so arranged that live parts are inaccessible when such supply circuits are energized.
6. Such cables shall be identified, and the identification shall meet the pertinent requirements of Rule 341B3.

EXCEPTION: The requirements of Rule 344A do not apply to communication circuits where the transmitted power does not exceed 150 W.

Section 35.
Direct-buried cable and cable in duct not part of a conduit system

NOTE: The term *duct* or *ducts* as used in this section refers to duct(s) not part of a conduit system.

350. General

A. Section 33 shall apply to direct-buried supply cable.

B. Cables operating above 600 V to ground shall have a continuous metallic shield, sheath, or concentric neutral that is effectively grounded.

EXCEPTION: At a splice or joint, the current path of the metallic shield, sheath, or neutral shall be made continuous but need not be concentric.

C. Cables meeting Rule 350B of the same supply circuit may be buried with no deliberate separation.

D. Cables of the same circuit operating below 600 V to ground and without an effectively grounded shield or sheath shall be placed in close proximity (no intentional separation) to each other.

E. Communication cables containing special circuits supplying power solely to communications equipment shall comply with the requirements of Rules 344A1 through 344A6.

F. All direct-buried jacketed supply cable meeting Rule 350B and all direct-buried communication cables shall be legibly marked as follows:

The appropriate identification symbol shown in Figure 350-1 shall be indented or embossed in the outermost cable jacket at a spacing of not more than 1 m (40 in). The symbol may be separate or sequentially combined with other data, or symbols, or both, printed on the jacket. If the symbol is sequentially combined, it shall be separated as indicated in Figure 350-1.

This rule became effective for cable installed on or after 1 January 1996.

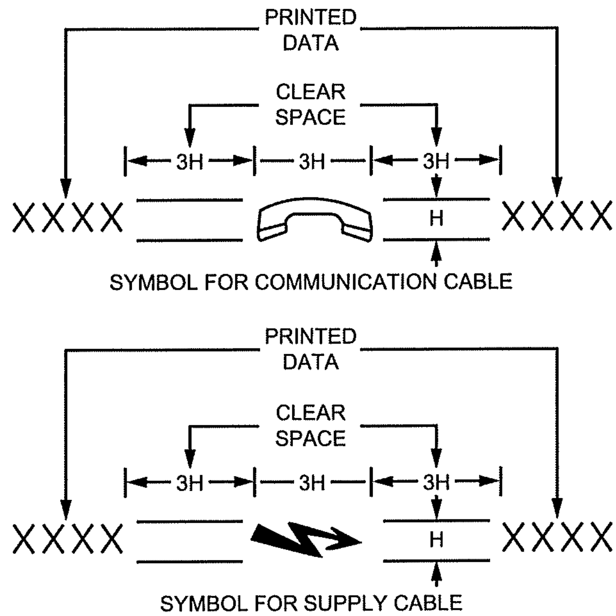
RECOMMENDATION: If color coding is used as an additional method of identifying cable, the American Public Works Association Uniform Color Code for marking underground utility lines is recommended.

EXCEPTION 1: Cables with jackets that cannot be effectively marked in accordance with Rule 350F need not be marked.

EXCEPTION 2: Unmarked cable from stock existing prior to 1 January 1996 may be used to repair unmarked direct-buried jacketed supply cables and communication cables.

G. The rules in this section shall also apply to supply and communication cables installed in duct that is not part of a conduit system.

RECOMMENDATION: If color coding is used as a method of identifying the duct, the American Public Works Association Uniform Color Code for marking underground utility lines is recommended.



H = Height of printed character; determined by cable manufacturer

Figure 350-1—Symbols for identification of buried cables

351. Location and routing

A. General

1. Cables should be located so as to be subject to the least disturbance practical. When cables are to be installed parallel to and directly over or under other subsurface structures, the rules on separation in Rule 353 or 354, as applicable, shall be followed.

2. Cables should be installed in as straight and direct a line as practical. Where bends are required, the bending radius shall be sufficiently large to limit the likelihood of damage to the cable being installed.

3. Cable systems should be routed so as to allow safe access for construction, inspection, and maintenance.

4. The location of structures in the path of the projected cable route shall, as far as practical, be determined prior to trenching, plowing, or boring operation.

B. Natural hazards

Routes through unstable soil such as mud, shifting soils, corrosive soils, or other natural hazards should be avoided. If burying is required through areas with natural hazards, the cables shall be constructed and installed in such a manner as to protect them from damage. Such protective measures should be compatible with other installations in the area.

C. Other conditions

1. Swimming pools (in-ground)

Supply cable should not be installed within 1.5 m (5 ft) horizontally of a swimming pool or its auxiliary equipment. If 1.5 m (5 ft) is not attainable, supplemental mechanical protection shall be provided.

NOTE: For aboveground pools, see Rule 351C2.

2. Buildings and other structures

   Cable should not be installed directly under the foundations of buildings or other structures, such as aboveground swimming pools, tanks, toolsheds, etc. Where a cable must be installed under such a structure, the foundation shall be suitably supported to limit the likelihood of transfer of a detrimental load onto the cable.

3. Railroad tracks

   a. The installation of cable longitudinally under the ballast section for railroad tracks should be avoided. Where cable must be installed longitudinally under the ballast section of a railroad, it should be located at a depth of not less than 1.27 m (50 in) below the top of the rail.

      EXCEPTION: Where this is not practical, or for other reasons, this burial depth may be reduced by agreement between the parties concerned.

      NOTE: Where unusual conditions exist or where proposed construction would interfere with existing installations, a greater depth than specified above would be required.

   b. Where a cable is installed under railroad tracks, the same burial depths indicated in Rule 320A5 shall apply.

4. Highways and streets

   The installation of cable longitudinally under traveled surfaces of highways and streets should be avoided. When cable must be installed longitudinally under the roadway, it should be installed in the shoulder or, if this is not practical, within the limits of one lane of traffic to the extent practical.

5. Water

   Cable or cable in duct installed under water should be routed, installed, or both, so that it will be protected from erosion by tidal action or currents. The cable or cable in duct should not be located where ships normally anchor.

6. Bridges

   Where permitted by the bridge owner, cables may be run in duct attached directly to the bridge. The duct shall be located so as to limit the likelihood of damage by traffic and be located to provide safe access for inspection or maintenance of both the bridge and the duct.

352. Installation

A. Trenching

   1. Direct-buried cable

      The bottom of the trench receiving direct-buried cable should be relatively smooth, undisturbed earth; well-tamped earth; or sand. When excavation is in rock or rocky soils, the cable should be laid on a protective layer of well-tamped backfill. Backfill within 100 mm (4 in) of the cable should be free of materials that may damage the cable. Backfill should be adequately compacted to limit settling under the expected surface usage. Machine compaction should not be used within 150 mm (6 in) of the cable.

   2. Cable in duct

      For cable installed in a duct, the bottom of the trench should be in undisturbed, tamped, or relatively smooth earth. Where the excavation is in rock, the duct should be laid on a protective layer of clean tamped backfill. All backfill should be free of materials that may damage the duct. Backfill should be adequately compacted to limit settling under the expected surface usage.

B. Plowing

1. Plowing in of cable in soil containing rock or other solid material should be done in such a manner that the solid material will not damage the cable, either during the plowing operation or afterward.
2. The design of cable-plowing equipment and the plowing-in operation should be such that the cable will not be damaged by bending, side-wall pressure, or excessive cable tension.

C. Boring

Where a cable system is to be installed by boring and the soil and surface loading conditions are such that solid material in the region may damage the cable, the cable shall be adequately protected.

D. Depth of burial

1. The distance between the top of a cable or duct and the surface under which it is installed (depth of burial) shall be sufficient to protect the cable or duct from damage imposed by expected surface usage.
2. Supply cable or duct shall have burial depths not less than the values indicated in Table 352-1.

   EXCEPTION: Where the burial depths required by Rule 352D2 cannot be met lesser depths than indicated in Table 352-1 may be used if supplemental mechanical protection is provided. The supplemental mechanical protection shall be sufficient to protect the cable or duct from damage imposed by expected surface usage. Where the cable is installed in duct, additional supplemental mechanical protection is not required if the duct is of sufficient strength to protect the cable from expected surface usage.

   NOTE 1: Cable depths at the time of installation may need to be adjusted to meet known grade changes.

   NOTE 2: In areas where frost conditions could damage cables or ducts, greater burial depths than indicated in Table 352-1 may be desirable.

E. Supply cables shall not be installed in the same duct with communication cables unless all of the cables are operated and maintained by the same utility.

F. Communication cables may be installed together in the same duct provided all utilities involved are in agreement.

Table 352-1—Supply cable, conductor, or duct burial depth
(See Rule 352D.)

Voltage (phase-to-phase)	Depth of burial	
	(mm)	(in)
0 to 600	600	24
601 to 50 000	750	30
50 001 and above	1070	42

EXCEPTION: Where conflicts with other underground facilities exist, street and area lighting cables operating at not more than 150 V to ground may be buried at a depth not less than 450 mm (18 in).

353. Deliberate separations—Equal to or greater than 300 mm (12 in) from underground structures or other cables

A. General

1. These rules apply to a radial separation of supply and communication cables or conductors from each other and from other underground structures such as sewers, water lines, gas and other lines that transport flammable material, building foundations, steam lines, etc., when separation is equal to or greater than 300 mm (12 in).

   NOTE: For radial separation less than 300 mm (12 in) see Rule 354.

2. The radial separation should be adequate to permit access to and maintenance of either facility to limit damage to the other.

B. Crossings

1. Where a cable crosses under another underground structure, the structure shall be suitably supported to limit the likelihood of transferring of a detrimental load onto the cable system.
2. Where a cable crosses over another underground structure, the cable shall be suitably supported to limit the likelihood of transferring a detrimental load onto the structure.
3. Adequate support may be provided by installing the facilities with sufficient vertical separation.

C. Parallel facilities

Where a cable system is to be installed directly over and parallel to another underground structure (or another underground structure installed directly over and parallel to a cable), it may be done providing all parties are in agreement as to the method. Adequate vertical separation shall be maintained to permit access to and maintenance of either facility without damage to the other cables.

D. Steam or cryogenic lines

Cable should be installed with sufficient separation from steam or cryogenic lines to limit the likelihood of thermal damage to the cable. Where it is not practical to provide adequate separation, a suitable thermal barrier shall be placed between the two facilities.

354. Random separation—Separation less than 300 mm (12 in) from underground structures or other cables

A. General

1. These rules apply to a radial separation of supply and communication cables or conductors from each other and from other underground structures when the radial separation between them will be less than 300 mm (12 in).
2. Radial separation of supply and communications cables or conductors from steam lines, gas, and other lines that transport flammable material shall be not less than 300 mm (12 in) and shall meet Rule 353.

   EXCEPTION: For supply cables operating at not more than 300 V between conductors, the radial separation may be less than required by Rule 354A2, provided supplemental mechanical protection is used to limit the likelihood of detrimental heat transfer to gas and other lines that transport flammable material due to a cable fault. For communication cables, the radial separation may be less than required by Rule 354A2. Agreement to the reduced separation by all utilities involved is required.

3. Supply circuits operating above 300 V to ground or 600 V between conductors shall be so constructed, operated, and maintained that when faulted, they shall be promptly de-energized initially or following subsequent protective device operation (phase-to-ground faults for effectively grounded circuits, phase-to-phase faults for ungrounded circuits).

4. Communication cables and conductors, and supply cables and conductors buried in random separation may be treated as one system when considering separation from other underground structures or facilities.

B. Supply cables or conductors

The cables or conductors of a supply circuit and those of another supply circuit may be buried together at the same depth with no deliberate separation between facilities, provided all parties involved are in agreement.

C. Communication cables or conductors

The cables or conductors of a communication circuit and those of another communication circuit may be buried together and at the same depth with no deliberate separation between facilities, provided all parties involved are in agreement.

D. Supply and communication cables or conductors

Supply cables or conductors and communication cables or conductors may be buried together at the same depth, with no deliberate separation between facilities, provided all parties involved are in agreement and the applicable rules in 354D1 are met and either Rule 354D2, 354D3, or 354D4 is met.

EXCEPTION: Entirely dielectric fiber-optic communication cables may be buried together at the same depth with no deliberate separation from supply cables or conductors provided all parties involved are in agreement and Rules 354D1a, b, c, and d are met.

1. General

   a. Grounded supply systems shall not be operated in excess of 22 000 V to ground.

   b. Ungrounded supply systems shall not be operated in excess of 5300 V phase to phase.

   c. Cables of an ungrounded supply system operating above 300 V shall be of effectively grounded concentric shield construction. Such cables shall be maintained in close proximity to each other.

   d. Ungrounded supply circuits operating above 300 V between conductors and in random separation with communication conductors shall be equipped with a ground-fault indication system.

   e. Communication cables and communication service wire having metallic conductors or metallic components shall have a continuous metallic shield under the outer jacket.

      EXCEPTION: This requirement does not apply to Rule 354C.

   f. Communications-protective devices shall be adequate for the voltage and currents expected to be impressed on them in the event of contact with the supply conductors.

   g. Adequate bonding shall be provided between the effectively grounded supply conductor or conductors and the communication cable shield or sheath at intervals that should not exceed 300 m (1000 ft).

      EXCEPTION: The bonding interval of Rule 354D1g may be increased for grounded supply conductors and communications cables in buried locations where adherence would require opening a duct and/or removing the protective jacket only for the purpose of installing a bond, provided all parties are in agreement.

   h. In the vicinity of supply stations where large ground currents may flow, the effect of these currents on communication circuits should be evaluated before communication cables are placed in random separation with supply cables.

2. Grounded bare or semiconducting jacketed neutral supply cables

   a. A supply facility operating above 300 V to ground shall include a bare or semiconducting jacketed grounded conductor in continuous contact with the earth. This conductor, adequate for the expected magnitude and duration of the fault current that may be imposed, shall be one of the following:

      (1) A sheath, an insulation shield, or both

(2) Multiple concentric conductors closely spaced circumferentially

(3) A separate conductor in contact with the earth and in close proximity to the cable, where such cable or cables also have a grounded sheath or shield not necessarily in contact with the earth. The sheath, shield, or both, as well as the separate conductor, shall be adequate for the expected magnitude and duration of the fault currents that may be imposed.

EXCEPTION: Where buried cable passes through a short section of conduit such as under a roadway, the contact with earth of the grounded conductor can be omitted, provided the grounded conductor is continuous through the conduit.

NOTE: This is applicable when a cable in nonmetallic duct is considered as a direct-buried cable installation and random separation is desired.

b. The bare conductor or conductors in contact with the earth shall be of suitable corrosion-resistant material. The conductor covered by a semiconducting jacket shall be compatible with the jacketing compound.

NOTE: Experience has shown that in many geographic areas, bare concentric copper neutral conductors experience severe corrosion.

c. The radial resistivity of the semiconducting jacket shall be not more than 100 Ω • m and shall remain essentially stable in service. The radial resistivity of the jacket material is that value calculated from measurements on a unit length of cable, of the resistance between the concentric neutral and a surrounding conducting medium. Radial resistivity is equal to the resistance of a unit length times the surface area of the jacket divided by the average thickness of the jacket over the neutral conductors. All dimensions are to be expressed in meters.

3. Insulating jacketed effectively grounded neutral supply cables

Each phase conductor of a multi-grounded supply system operating above 300 V to ground and having an overall insulating jacket shall have an effectively grounded copper concentric conductor meeting all of the following requirements:

a. Adequate for the expected magnitude and duration of fault current that may be imposed

b. Effectively grounded as required by Rule 314 except that the number of grounding electrodes shall be not less than eight in each 1.6 km (1 mile) of the random buried section, not including grounds at individual services

EXCEPTION: The grounding interval of Rule 354D3b may be increased for grounded neutral supply cables with insulating jackets where adherence would require opening a duct and/or removing the protective jacket of the buried cable only for the purpose to install a ground connection. For such cases, the supply circuit shall be effectively grounded where the cable does become accessible.

4. Insulating jacketed grounded neutral supply cables in nonmetallic duct

Insulating jacketed grounded neutral supply cables meeting the rules of 354D3, when installed in nonmetallic duct, may be random-laid with communication cables.

E. Supply and communication cables or conductors and non-metallic water and sewer lines

1. Supply cables and conductors and non-metallic water and sewer lines may be buried together with no deliberate separation between facilities and at the same depth, provided all parties involved are in agreement.

2. Communication cables and conductors and non-metallic water and sewer lines may be buried together with no deliberate separation between facilities and at the same depth, provided all parties involved are in agreement.

3. Supply cables or conductors, communication cables or conductors, non-metallic water and sewer lines may be buried together with no deliberate separation between facilities and at the same depth, provided the applicable rules in Rule 354D are met and all parties involved are in agreement.

355. Additional rules for duct not part of a conduit system

A. Duct material shall be corrosion-resistant and suitable for the intended environment.

B. The internal surface of the duct shall be free of sharp edges or burrs, which could damage the supply or communication cable.

C. Ducts shall be joined in a manner so as to limit solid matter from entering the duct line. Joints shall form a sufficiently continuous smooth interior surface between joining duct sections so that the supply or communication cable will not be damaged when pulled past the joint.

D. The portion of duct installed through ~~a~~ an exterior building wall, floor, or roof shall have seals inside the duct and external seals on the outside surface of the duct at the point of entry into the building intended to limit the likelihood of the entrance of gas into the building. The use of seals may be supplemented by gas-venting devices in order to limit the buildup of positive gas pressures in the conduit.

Section 36. Risers

360. General

A. Mechanical protection for supply conductors or cables shall be provided as required by Rule 239D of this Code. This protection should extend at least 300 mm (1 ft) below ground level.

B. Supply conductors or cable should rise vertically from the cable trench with only such deviation as necessary to permit a reasonable cable-bending radius.

C. Exposed conductive ducts or guards containing supply conductors or cables shall be effectively grounded-as required by Rule 314B.

361. Installation

A. The installation should be designed so that water does not stand in riser pipes above the frost line.

B. Conductors or cables shall be supported in a manner designed to limit the likelihood of damage to conductors, cables, or terminals.

C. Where conductors or cables enter the riser pipe or elbow, they shall be installed in such a manner that shall minimize the possibility of damage due to relative movement of the cable and pipe.

362. Pole risers—Additional requirements

A. Risers should be located on the pole in the safest available position with respect to climbing space and exposure to traffic damage.

B. The number, size, and location of riser ducts or guards shall be limited to allow adequate access for climbing.

363. Pad-mounted installations

A. Supply conductors or cables rising from the trench to transformers, switchgear, or other equipment mounted on pads shall be so placed and arranged that they will not bear on the edges of holes through the pad nor the edges of bends or other duct work below the pad.

B. Cable entering pad-mounted equipment shall be maintained substantially at adequate depth for the voltage class until it becomes protected by being directly under the pad, unless other suitable mechanical protection is provided.

Section 37.
Supply cable terminations

370. General

A. Cable terminations shall be designed and constructed to meet the requirements of Rule 333.

B. Riser terminations not located within a vault, pad-mounted equipment, or similar enclosure shall be installed in a manner designed to ensure that the clearance specified in Parts 1 and 2 of this Code are maintained.

C. A cable termination shall be designed to limit the likelihood of moisture penetration into the cable where such penetration is detrimental to the cable.

D. Where clearances between parts at different potentials are reduced below those adequate for the voltage and BIL (basic impulse insulation level), suitable insulating barriers or fully insulated terminals shall be provided to meet the required equivalent clearances.

371. Support at terminations

A. Cable terminations shall be installed in a manner designed to maintain their installed position.

B. Where necessary, cable shall be supported or secured in a manner designed to limit the likelihood of the transfer of damaging mechanical stresses to the termination, equipment, or structure.

372. Identification

Suitable circuit identification shall be provided for all terminations.

EXCEPTION: This requirement does not apply where the position of the termination, in conjunction with diagrams or maps supplied to workers, gives sufficient identification.

373. Clearances in enclosures or vaults

A. Adequate electrical clearances of supply terminations shall be maintained, both between conductors and between conductors and ground, consistent with the type of terminator used.

B. Where exposed live parts are in an enclosure, clearances or insulating barriers adequate for the voltages and the design BIL shall be provided.

C. Where a termination is in a vault, uninsulated live parts are permissible provided they are guarded or isolated.

374. Grounding

A. All exposed conducting surfaces of the termination device, other than live parts and equipment to which it is attached, shall be effectively grounded, bonded, or both.

B. Conductive structures supporting cable terminations shall be effectively grounded.

EXCEPTION: Grounding, bonding, or both is not required where the above parts are isolated or guarded.

Section 38.
Equipment

380. General

A. Equipment includes:

1. Buses, transformers, switches, etc., installed for the operation of the electric supply system
2. Repeaters, loading coils, etc., installed for the operation of the communications system
3. Auxiliary equipment, such as sump pumps, convenience outlets, etc., installed incidental to the presence of the supply or communications systems

B. Where equipment is to be installed in a joint-use manhole, it shall be done with the concurrence of all parties concerned.

C. Supporting structures, including racks, hangers, or pads and their foundations, shall be designed to sustain all loads and stresses expected to be imposed by the supported equipment including those stresses caused by its operation.

D. Pad-mounted equipment, pedestals, and other aboveground enclosures, should be located not less than 1.2 m (4 ft) from fire hydrants.

EXCEPTION 1: Where conditions do not permit a clearance of 1.2 m (4 ft), a clearance of not less than 900 mm (3 ft) is allowed.

EXCEPTION 2: Clearances in Rule 380D may be reduced by agreement with the local fire authority and the equipment owner.

381. Design

A. The expected thermal, chemical, mechanical, and environmental conditions at the location shall be considered in the design of all equipment and mountings.

B. All equipment, including auxiliary devices, shall be designed to withstand the effects of normal, emergency, and fault conditions expected during operation.

C. Switches shall be provided with clear indication of contact position, and the handles or activating devices clearly marked to indicate operating directions.

D. Remotely controlled or automatic devices shall have local provisions to render remote or automatic controls inoperable if such operation may result in a hazard to the worker.

E. Enclosures containing fuses and interrupter contacts shall be designed to withstand the effects of normal, emergency, and fault conditions expected during operation.

F. When tools are to be used to connect or disconnect energized devices, space or barriers shall be designed to provide adequate clearance from ground or between phases.

G. Pad-mounted and other aboveground equipment

1. Pad-mounted and other aboveground equipment shall have an enclosure that is either locked or otherwise secured against unauthorized entry.
2. Access to exposed live parts in excess of 600 V shall require two separate conscious acts. The first shall be the opening of a door or barrier that is locked or otherwise secured against unauthorized entry as required by Rule 381G1. The second act shall be either the opening of a door or the removal of a barrier.

   A prominent and appropriate safety sign should be visible when the first door or barrier is opened or removed.

   NOTE: ANSI Z535.1-2011, ANSI Z535.2-2011, ANSI Z535.3-2011, and ANSI Z535.4-2011 contain information regarding safety signs.

382. Location in underground structures

A. Equipment shall not obstruct personnel access openings in manholes or vaults, nor shall it impede egress by persons working in the structures containing the equipment.

B. Equipment shall not be installed closer than 200 mm (8 in) to the back of fixed ladders and shall not interfere with the proper use of such ladders.

C. Equipment should be arranged in a manhole or vault to permit installation, operation, and maintenance of all items in such structures.

D. Switching devices that have provision for manual or electrical operation shall be operable from a safe position. This may be accomplished by use of portable auxiliary devices, temporarily attached.

E. Equipment should not interfere with drainage of the structure.

F. Equipment shall not interfere with the ability to ventilate any structure or enclosure.

383. Installation

A. Provisions for lifting, rolling to final position, and mounting shall be adequate for the weight of the device.

B. Live parts shall be guarded or isolated to limit the likelihood of contact by persons in a normal position adjacent to the equipment.

C. Operating levers, inspection facilities, and test facilities shall be visible and readily accessible when equipment is in final location without moving permanent connections.

D. Live parts shall be isolated or protected from exposure to conducting liquids or other material expected to be present in the structure containing the equipment.

E. Operating controls of supply equipment, readily accessible to unauthorized personnel, shall be secured by bolts, locks, or seals.

384. Grounding and bonding

A. Cases and enclosures made of conductive material shall be effectively grounded or guarded.

B. Guards constructed of conductive material shall be effectively grounded.

C. Bonding should be provided between all aboveground metallic supply and communications enclosures that are separated by a distance of 1.8 m (6 ft) or less. For the purpose of this rule, pole grounds are not required to be bonded to the communication enclosure.

NOTE: This rule does not prohibit bonding communication metallic enclosures to supply pole grounds, provided all affected parties are in agreement.

385. Identification

Where transformers, regulators, or other similar equipment operate in multiple, tags, diagrams, or other suitable means shall be used to indicate that fact.

Section 39. Installation in tunnels

390. General

A. The installation of supply and communications facilities in tunnels shall meet the applicable requirements contained elsewhere in Part 3 of this Code as supplemented or modified by this section.

B. Where the space occupied by supply or communications facilities in a tunnel is accessible to other than qualified persons, or where supply conductors do not meet the requirements of Part 3 of this Code for cable systems, the installation shall be in accordance with the applicable requirements of Part 2 of this Code.

C. All parties concerned must be in agreement with the design of the structure and designs proposed for installations within it.

391. Environment

A. When the tunnel is accessible to the public or when workers must enter the structure to install, operate, or maintain the facilities in it, the design shall provide a controlled safe environment including, where necessary, barriers, detectors, alarms, ventilation, pumps, and adequate safety devices for all facilities. Controlled safe environment shall include the following:

   1. Design to avoid poisonous or suffocation atmosphere

   2. Design to protect persons from pressurized lines, fire, explosion, and high temperatures

   3. Design to avoid unsafe conditions due to induced voltages

   4. Design to limit the likelihood of hazards due to flooding

   5. Design to ensure egress; two directions for egress shall be provided for all points in tunnels

   6. Working space, in accordance with Rule 323B, the boundary of which shall be not less than 600 mm (2 ft) from a vehicular operating space or from exposed moving parts of machinery

   7. Safeguards designed to protect workers from hazards due to the operation of vehicles or other machinery in tunnels

   8. Unobstructed walkways for workers in tunnels

B. A condition of occupancy in multiple-use tunnels by supply and communications facilities shall be that the design and installation of all facilities is coordinated to provide a safe environment for the operation of supply facilities, communications facilities, or both. Safe environment for facilities shall include the following:

   1. Means to protect equipment from harmful effects of humidity or temperature

   2. Means to protect equipment from harmful effects of liquids or gases

   3. Coordinated design and operation of corrosion-control systems

Part 4.
Work Rules for the Operation of Electric Supply and Communications Lines and Equipment

Section 40.
Purpose and scope

400. Purpose

The purpose of Part 4 of this Code is to provide practical work rules as one of the means of safeguarding employees and the public from injury. It is not the intent of these rules to require unreasonable steps to comply; however, all reasonable steps shall be taken.

401. Scope

Part 4 of this Code covers work rules to be followed in the installation, operation, and maintenance of electric supply and communications systems.

402. Referenced sections

The Introduction (Section 1), Definitions (Section 2), References (Section 3), and Grounding methods (Section 9) of this Code shall apply to the requirements of Part 4.

The standards listed in Section 3 (References) shall be used with Part 4 where applicable.

Section 41. Supply and communications systems—Rules for employers

410. General requirements

A. General

1. The employer shall inform each employee working on or in the vicinity of communications equipment or electric supply equipment and the associated lines, of the safety rules governing the employee's conduct while so engaged.

   When deemed necessary, the employer shall provide a copy of such rules.

2. The employer shall provide training to all employees who work on or in the vicinity of exposed energized lines and parts. The training shall include applicable work rules required by this Part and other mandatory referenced standards or rules. The employer shall ensure that each employee has demonstrated proficiency in required tasks. The employer shall provide retraining for any employee who, as a result of routine observance of work practices, is not following work rules.

3. The employer shall ensure that an assessment is performed to determine potential exposure to an electric arc for employees who work on or near energized lines, parts, or equipment.

   If the assessment determines potential employee exposure, employees shall not wear any clothing made from acetate, nylon, polyester, or polypropylene unless arc rated, and shall not wear an outer layer of clothing that could ignite and continue to burn when exposed to flames or the electric arc identified in the assessment.

   If the assessment determines a potential employee exposure greater than 2 cal/cm^2 exists (see Neal, Bingham, and Doughty [B62]), the employer shall:

   a. Perform a detailed arc hazard analysis, or use Table 410-1, Table 410-2, or Table 410-3 to determine the effective arc rating of clothing to be worn by employees working on or near energized lines, parts, or equipment at voltages 50 V to 800 000 V.

      The arc hazard analysis shall include a calculation of the estimated arc energy based on the available fault current, the duration of the arc (cycles), and the distance from the arc to the employee.

   b. Require employees to cover the entire body with arc rated clothing and equipment having an effective arc rating not less than the anticipated level of arc energy.

   EXCEPTION 1: If the clothing required by this rule has the potential to create additional or greater hazards than the possible exposure to the heat energy of the electric arc, then clothing with an effective arc rating less than that required by the this rule may be worn.

   EXCEPTION 2: Arc-rated equipment is not necessary for the employee's hands when the employee is wearing rubber insulating gloves with protectors. Heavy-duty leather work gloves with a weight of at least 407 gm/m^2 (12 oz/yd^2) may be worn if the estimated incident energy is no more than 14 cal/cm^2.

   EXCEPTION 3: Arc-rated equipment is not necessary for the employee's feet when the employee is wearing heavy-duty work shoes or boots.

   EXCEPTION 4: Arc-rated equipment is not necessary for the employee's head or face when the employee is wearing head protection meeting 29 CFR 1910.135 [B66] if the estimated incident energy is less than OSHA 9 cal/cm^2 for exposures involving single phase arcs in open air less than or 5 cal/cm^2 for other exposures. Arc-rated equipment is necessary for the protection of the employee's head and face and may consist of head protection meeting OSHA 29 CFR 1910.135 and a face shield with a minimum arc rating of 8 cal/cm^2 if the estimated incident-energy exposure is greater than 9 cal/cm^2 and less than 13 cal/cm^2 for exposures involving single-phase arcs in open air or greater than 5 cal/cm^2 and less than 9 cal/cm^2 for other exposures. For exposures involving single phase arcs in open air, the arc rating for the employee's head and face protection may be 4 cal/cm^2 less than the estimated incident energy.

EXCEPTION 5: For dc systems with voltages from 50 V to 250 V and 8000 A maximum fault current, in lieu of performing an arc hazard analysis, clothing with a minimum effective arc rating of 5 cal/cm^2 shall be used (see Doan, "Arc Flash Calculations for Exposures to DC Systems").

NOTE 1: See Doan, "Arc Flash Calculations for Exposures to DC Systems" [B28].

NOTE 2: Assessments performed to determine potential exposure to an electric arc consider the affected employee's assigned tasks and/or work activities.

NOTE 3: Multiple layers of arc rated clothing (e.g., shirts, pants, and jackets) have been shown by testing to block more heat than a single layer.

NOTE 4: Clothing includes normal garments such as shirts, pants, jackets, and coveralls, whether in single or multiple layers.

NOTE 5: Engineering controls can be utilized to reduce arc energy levels and work practices can be utilized to reduce exposure levels.

4. Employers shall utilize positive procedures to secure compliance with these rules. Cases may arise where the strict enforcement of a particular rule could seriously impede the safe progress of the work; in such cases the employee in charge of the work should make a temporary modification to the particular rule so the work can be accomplished without increasing the hazard.

5. If a difference of opinion arises with respect to the application of these rules, the decision of the employer or the employer's authorized agent shall be final. This decision shall not result in any employee performing work in a manner that is unduly hazardous to the employee or to other workers.

6. The employer shall provide training to all employees who work in the vicinity of antennas operating in the range of 3 kHz to 300 GHz to recognize and mitigate exposure to radio-frequency sources that exceed exposure levels set forth by the regulatory authority having jurisdiction.

   NOTE: See OSHA 29 CFR 1910.97, Subpart G [B65]; OSHA 29 CFR 1910.268, Subpart R [B67]; FCC Bulletin No. 65 [B30]; IEEE Std C95.1-2005 [B60].

B. Emergency and first aid procedures

1. Employees shall be informed of the procedures to be followed in case of emergencies and first aid including approved methods of resuscitation. Copies of such procedures should be accessible where the number of employees and the nature of the work warrants.

2. Employees working on communications or electric supply equipment or lines shall be regularly instructed in methods of first aid and emergency procedures, if their duties warrant such training.

C. Responsibility

1. A designated person shall be in charge of the operation of the equipment and lines and shall be responsible for their safe operation.

2. If more than one person is engaged in work on or in the vicinity of the same equipment or line, one person shall be designated as in charge of the work to be performed. Where there are separate work locations, one person may be designated at each location.

Table 410-1—Clothing and clothing systems (cal/cm^2) for voltages 50 V to 1000 V (ac) ①

(See Rule 410A3.)

Equipment type	Nominal voltage range and cal/cm^2		
	50 V to 250 V	**251 V to 600 V⑭**	**601 V to 1000 V**
Self-contained meters / cabinets	4 ②	20 ④	30 ⑧
Pad-mounted transformers	4 ⑨	4 ⑨	6 ⑧
CT meters and control wiring	4 ②	4 ⑤	6 ⑧
Metal-clad switchgear / motor control centers	8 ③	40 ⑥	60 ⑧
Pedestals / pull boxes / hand holes	4 ②	8 ⑦	12 ⑧
Open air (includes lines)	4 ②	4 ⑦	6 ⑧
Network protectors	4⑩	⑪	⑪
Panel boards—single phase (all) / three phase (≤100 A)	4②	8⑫	12⑧
Panel boards—three phase (>100 A)	4②	⑬	⑬

①This table was developed from fault testing based on equipment type and is independent of fault current unless otherwise noted.

Calculations and test data are based on a 46 cm (18 in) separation distance from the arc to the employee. See IEEE Std 1584-2002.

Other methods are available to estimate arc exposure values and may yield slightly different but equally acceptable results.

The use of the table in the selection of clothing is intended to reduce the amount or degree of injury but may not prevent all burns.

②Industry testing on this equipment by two separate major utilities and a research institute has demonstrated that voltages 50 V to 250 V will not sustain arcs for more than 2 cycles, thereby limiting exposure to less than 4 cal/cm^2. (See *208-V Arc Flash Testing* [B1].)

③Value based on IEEE 1584 formula for Motor Control Centers. [Gap = 2.54 cm (1 in)] (Xd = 1.641) [46 cm (18 in) distance] 51 kA (Based on a 208 V, 1000 kVA, 5.3% Z, served from a 500 MVA system) Maximum duration without circuit protective device operation from industry testing (see *208-V Arc Flash Testing* [B1]) is 10 cycles: 46.5 cal/s/cm^2 x 0.167 s = 7.8 cal/cm^2.

④Industry testing on 480 V-200 A, self-contained, Form 16S, single-socket meter cabinet indicates exposures do not exceed 20 cal/cm^2 [B2] Testing on 480 V 400 A, Class 320-A meter sockets and multi-meter panels (with large amounts of internal exposed bus bar) indicates higher heat flux rates and do not self-extinguish similar to larger power panels. (See Footnote 13 and *480-V Distribution Arc Flash Updates* [B2].

⑤Industry testing on 480 V equipment indicates exposures for CT meters and control wiring does not exceed 4 cal/cm^2.

⑥Value based on IEEE 1584 formula for Motor Control Centers. [Gap = 2.54 cm (1 in)] (Xd = 1.641) [46 cm (18 in) distance] 12.7 kA at 480 V (worst-case energy value from testing). (See Eblen and Short [B29].) Maximum duration without circuit protective device operation from tests is 85 cycles: 26.2 cal/s/cm^2 x 1.42 s = 37 cal/cm^2.

⑦Incident analysis on this equipment indicates exposures do not exceed the values in the table.

⑧Engineering analysis indicates that applying a 150% multiplier to the 480 V exposure values provides a conservative value for equipment and open air lines operating at 601 V to 1000 V.

⑨Industry testing on 480 V equipment indicates exposures on pad-mounted transformers do not exceed 4 cal/cm^2. (See Eblen and Short [B29].)

⑩Industry testing on 208 V network protectors indicates exposures do not exceed 4 cal/cm^2. (See *208-V Arc Flash Testing* [B1].)

⑪Industry testing on 480 V network protectors indicates arcs will not self-extinguish and heat flux rates will exceed 60 cal/cm^2/s at 24 in working distance. Perform arc hazard analysis. (See Eblen and Short [B29].)

⑫Industry testing on 480 V panels with non-edge mounted bus bars indicates exposures do not exceed 8 cal/cm^2. (See Eblen and Short [B29].)

⑬Industry testing on panelboards with edge-mounted, parallel bus bars indicate arcs will not self-extinguish and heat flux rates will exceed 60 $cal/cm^2/s$ at 46 cm (18 in) working distance. Perform arc hazard analysis. (See Eblen and Short [B29].)

⑭IEEE 1584 original test data indicates there is no significant difference between heat flux rates for 400 V class equipment verses 600 V class equipment.

Table 410-2—Clothing and clothing systems—voltage, fault current, and maximum clearing time for voltages 1.1 kV to 46 kV ac ①

(See Rule 410A3.)

Phase-to-phase voltage (kV)	Fault current (kA)	4-cal system	8-cal system	12-cal system
		Maximum clearing time (cycles)	Maximum clearing time (cycles)	Maximum clearing time (cycles)
1.1 to 15	5	46.5	93.0	139.5
	10	18.0	36.1	54.1
	15	10.0	20.1	30.1
	20	6.5	13.0	19.5
15.1 to 25	5	27.6	55.2	82.8
	10	11.4	22.7	34.1
	15	6.6	13.2	19.8
	20	4.4	8.8	13.2
25.1 to 36	5	20.9	41.7	62.6
	10	8.8	17.6	26.5
	15	5.2	10.4	15.7
	20	3.5	7.1	10.6
36.1 to 46	5	16.2	32.4	48.6
	10	7.0	13.9	20.9
	15	4.3	8.5	12.8
	20	3.0	6.1	9.1

①These calculations are based on open air phase-to-ground arc. This table is not intended for phase-to-phase arcs or enclosed arcs (arc in a box).

These calculations are based on a 15-in separation distance from the arc to the employee and arc gaps as follows: 1 kV to 15 kV = 5.08 cm (2 in), 15.1 kV to 25 kV = 10.16 cm (4 in), 25.1 kV to 36 kV = 15.24 cm (6 in), 36.1 kV to 46 kV = 22.86 cm (9 in). See IEEE Std 4-1995.

These calculations were derived using a commercially available computer software program. Other methods are available to estimate arc exposure values and may yield slightly different but equally acceptable results.

The use of the table in the selection of clothing is intended to reduce the amount or degree of injury but may not prevent all burns.

Table 410-3—Live-line tool work clothing and clothing systems—voltage, fault current, and maximum clearing time for voltages 46.1 kV to 800 kV ac①
(See Rule 410A3.)

Phase-to-phase voltage (kV)	Fault current (kA)	4-cal system	8-cal system	12-cal system
		Maximum clearing time (cycles)	Maximum clearing time (cycles)	Maximum clearing time (cycles)
46.1 to 72.5	20	18.2	36.4	54.5
	30	10.2	20.4	30.6
	40	6.6	13.2	19.7
	50	4.6	9.2	13.9
72.6 to 121	20	9.9	19.8	29.8
	30	5.7	11.4	17.1
	40	3.8	7.5	11.3
	50	2.7	5.4	8.1
138 to 145	20	12.1	24.1	36.2
	30	7.4	14.9	22.3
	40	5.2	10.4	15.6
	50	3.9	7.8	11.7
161 to 169	20	11.9	23.9	35.8
	30	7.4	14.8	22.2
	40	5.2	10.3	15.5
	50	3.9	7.8	11.6
230 to 242	20	13.6	27.3	40.9
	30	8.4	16.8	25.2
	40	5.9	11.7	17.6
	50	4.4	8.8	13.2
345 to 362	20	26.4	52.7	79.1
	30	16.2	32.4	48.6
	40	11.3	22.6	34.0
	50	8.5	17.0	25.5
500 to 550	20	23.1	46.2	69.2
	30	14.2	28.4	42.6
	40	10.0	19.9	29.9
	50	7.5	15.0	22.4

Table 410-3—Live-line tool work clothing and clothing systems—voltage, fault current, and maximum clearing time for voltages 46.1 kV to 800 kV ac① *(continued)*
(See Rule 410A3.)

Phase-to-phase voltage (kV)	Fault current (kA)	4-cal system	8-cal system	12-cal system
		Maximum clearing time (cycles)	Maximum clearing time (cycles)	Maximum clearing time (cycles)
765 to 800	20	25.3	50.5	75.8
	30	15.6	31.2	46.8
	40	10.9	21.7	32.6
	50	8.2	16.3	24.5

①Arc gap—calculated by using the phase-to-ground voltage of the circuit and dividing by 10. The dielectric strength of air is taken at 10 kV per inch. See IEEE Std 4-1995.

Distance from arc—calculated by using the minimum approach distance from Table 441-1, subtracting two times the assumed arc gap length, and using the following T values: 72.6 kV to 362 kV = 3.0, 362.1 kV to 550 kV = 2.4, 550.1 kV to 800 kV = 2.0.

These calculations were derived using a commercially available computer software program. Other methods are available to estimate arc exposure values and may yield slightly different, but equally acceptable results.

The use of the table in the selection of clothing is intended to reduce the amount or degree of injury but may not prevent all burns.

411. Protective methods and devices

A. Methods

1. Access to rotating or energized equipment shall be restricted to authorized personnel.
2. Diagrams, showing plainly the arrangement and location of the electric supply equipment and lines, shall be maintained on file and shall be readily available to authorized personnel for that portion of the system for which they are responsible.
3. Employees shall be instructed as to the characteristics of the equipment or lines and methods to be used before any work is undertaken thereon.
4. Employees should be instructed to take additional precautions to ensure their safety when conditions create unusual hazards.

B. Devices and equipment

An adequate supply of protective devices and equipment, sufficient to enable employees to meet the requirements of the work to be undertaken, and first aid equipment and materials shall be available in readily accessible and, where practical, conspicuous places.

Protective devices and equipment shall conform to the applicable standards listed in Section 3.

NOTE: The following is a list of some common protective devices and equipment, the number and kinds of which will depend upon the requirements of each case:

1. Insulating wearing apparel such as rubber gloves, rubber sleeves, and headgear
2. Insulating shields, covers, mats, and platforms
3. Insulating tools for handling or testing energized equipment or lines
4. Face and eye protection
5. *Person at work* tags, portable danger signs, traffic cones, and flashers
6. Line worker's body belts, lanyards, and positioning straps

7. Fire-extinguishing equipment designed for safe use on energized parts or plainly marked that they must not be so used
8. Protective grounding materials and devices
9. Portable lighting equipment
10. First aid equipment and materials
11. Voltage detection devices/meters

C. Inspection and testing of protective devices and equipment

1. Protective devices and equipment shall be inspected or tested to ensure that they are in safe working condition.
2. Insulating gloves, sleeves, and blankets shall be inspected before use. Insulating gloves and sleeves shall be tested as frequently as their use requires.
3. Before use, climbing and fall protection equipment shall be inspected to ensure that they are in safe working condition.

D. Signs and tags for employee safety

Safety signs and tags required by Part 4, when installed or replaced, shall comply with the provisions of the current editions of ANSI Z535.1 through ANSI Z535.5, inclusive.

E. Identification and location

Means shall be provided so that identification of supply and communication lines can be determined before work is undertaken. Persons responsible for underground facilities shall be able to indicate the location of their facilities.

F. Fall protection

1. Employers shall develop, implement, and maintain an effective fall protection program applicable to climbing or otherwise accessing and working from elevated work locations, which shall include all of the following:
   a. Training, retraining, and documentation
   b. Guidance on equipment selection, inspection, care, and maintenance
   c. Considerations concerning structural design and integrity, with particular reference to anchorages and their availability
   d. Rescue plans and related training
   e. Hazard recognition
2. The employer shall not permit the use of 100% leather positioning straps or non-locking snap hooks.

Section 42.
General rules for employees

420. General

A. Rules and emergency methods

1. Employees shall carefully read and study the safety rules, and may be called upon at any time to show their knowledge of the rules.
2. Employees shall familiarize themselves with approved methods of first aid, rescue techniques, and fire extinguishment.

B. Qualifications of employees

1. Employees whose duties require working on or in the vicinity of energized equipment or lines shall perform only those tasks for which they are trained, equipped, authorized, and so directed. Inexperienced employees shall: (a) work under the direction of an experienced and qualified person at the site, and (b) perform only directed tasks.
2. Employees operating mechanized equipment shall be qualified to perform those tasks.
3. If an employee is in doubt as to the safe performance of any assigned work, the employee shall request instructions from the employee's supervisor or person in charge.
4. Employees who do not normally work on or in the vicinity of electric supply lines and equipment but whose work brings them into these areas for certain tasks shall proceed with this work only when authorized by a qualified person.

C. Safeguarding oneself and others

1. Employees shall heed safety signs and signals and warn others who are in danger or in the vicinity of energized equipment or lines.
2. Employees shall report promptly to the proper authority any of the following:
    a. Line or equipment defects such as abnormally sagging wires, broken insulators, broken poles, or lamp supports
    b. Accidentally energized objects such as conduits, light fixtures, or guys
    c. Other defects that may cause a dangerous condition
3. Employees whose duties do not require them to approach or handle electric equipment and lines shall keep away from such equipment or lines and should avoid working in areas where objects and materials may be dropped by persons working overhead.
4. Employees who work on or in the vicinity of energized lines shall consider all of the effects of their actions, taking into account their own safety as well as the safety of other employees on the job site, or on some other part of the affected electric system, the property of others, and the public in general.
5. No employee shall approach or bring any conductive object, without a suitable insulating handle, closer to any exposed energized part than allowed by Rule 431 (communication) or Rule 441 (supply), as applicable.
6. Employees should exercise care when extending metal ropes, tapes, or wires parallel to and/or in the vicinity of energized high-voltage lines because of induced voltages. When it is necessary to measure clearances from energized objects, only devices approved for the purpose shall be used.

D. Energized or unknown conditions

Employees shall consider electric supply equipment and lines to be energized, unless they are positively known to be de-energized. Before starting work, employees shall perform preliminary inspections or tests to determine existing conditions. Operating voltages of equipment and lines should be known before working on or in the vicinity of energized parts.

E. Ungrounded metal parts

Employees shall consider all ungrounded metal parts of equipment or devices such as transformer cases and circuit breaker housings, to be energized at the highest voltage to which they are exposed, unless these parts are known by test to be free from such voltage.

F. Arcing conditions

Employees should keep all parts of their bodies as far away as practical from switches, brushes, commutators, circuit breakers, or other parts at which arcing may occur during operation or handling.

G. Liquid-cell batteries

1. Employees shall ascertain that battery areas are adequately ventilated before performing work.
2. Employees should avoid smoking, using open flames, or using tools that may produce sparks in the vicinity of liquid-cell batteries.
3. Employees shall use eye and skin protection when handling an electrolyte.
4. Employees shall not handle energized parts of batteries unless necessary precautions are taken to avoid short circuits and electrical shocks.

H. Tools and protective equipment

Employees shall use the personal protective equipment, the protective devices, and the special tools provided for their work. Before starting work, these devices and tools shall be carefully inspected to make sure that they are in good condition.

I. Clothing

1. Employees shall wear clothing suitable for the assigned task and the work environment.
2. When employees will be exposed to an electric arc, clothing or a clothing system shall be worn in accordance with Rule 410A3.
3. When working in the vicinity of energized lines or equipment, employees should avoid wearing exposed metal articles.

J. Ladders and supports

1. Employees shall not support themselves, or any material or equipment, on any portion of a tree, pole structure, scaffold, ladder, walkway, or other elevated structure or aerial device, etc., without it first being determined, to the extent practical, that such support is adequately strong, in good condition, and properly secured in place.
2. Portable wood ladders intended for general use shall not be painted except with a clear nonconductive coating, nor shall they be longitudinally reinforced with metal.
3. Portable metal ladders intended for general use shall not be used when working on or in the vicinity of energized parts.
4. If portable ladders are made partially or entirely conductive for specialized work, necessary precautions shall be taken to ensure that their use will be restricted to the work for which they are intended.

K. Fall protection

1. Employees shall use appropriate fall protection equipment while climbing, transferring, or transitioning across obstacles on poles or structures, unless doing so is not feasible or creates a greater hazard than doing so unattached.
   a. When work positioning is used, it shall be rigged in a manner in which the employee cannot free fall more than 0.60 m (2 ft).
   b. Anchorages for work-positioning equipment shall be capable of supporting at least twice the potential impact load of an employee's fall, or 13.3 kN (3000 lb-force), whichever is greater.

NOTE 1: Wood-pole fall-restriction devices meeting American Society of Testing and Materials *Standard Specifications for Personal Climbing Equipment,* ASTM F 887-04 [B23] or later versions, are deemed to meet the anchorage-strength requirement when they are used in accordance with manufacturers' instructions.

NOTE 2: Recognized and generally accepted good engineering practices, with consideration given to such factors as design specifications and maintenance procedures, may be used in determining whether potential anchorages meet the strength requirements in 420K1b provided the employee performs a visual inspection before use that reveals nothing about the appearance of the anchorage (for example, corrosion around support-member connections or bent support members) suggests that the applicable strength criteria would not be met.

NOTE 3: On poles, when the employee is transitioning or at the work location and the work positioning strap is positioned above a bolted attachment, step bolt, or other equipment, these attachments may serve as the anchorage. It is not necessary to determine the strength of the attachment provided the employee performs a visual inspection before use that reveals nothing about the appearance of the anchorage (for example, corrosion or cracks) suggests that the applicable strength criteria would not be met.

2. At elevated locations above 1.2 m (4 ft) employees shall use a fall protection system while working on poles, towers, or similar structures, or while working at elevated locations from aerial lifts, helicopters, cable carts, or similar devices.

3. Fall protection equipment shall be inspected before use by the employee to ensure that the equipment is in safe working condition.

4. Fall arrest equipment shall be attached to a suitable anchorage.

5. The employee shall determine that all components of the fall protection system are properly engaged and that the employee is secure in the line-worker's body belt, harness, or any other fall protection system.

   NOTE: Climbers need to be aware of accidental disengagement of fall protection components. Accidental disengagement is the sudden, unexpected release of a positioning strap snap hook from the D-ring of the line-worker's body belt without the user directly manipulating the latch of the snap hook. In general, there are two primary reasons for this occurrence.

   (a) Foreign objects may open the latch of the snap hook during normal use. It is possible for the snap hook to come in contact with such things as hand lines, guy wires, or other apparatus. These items may place pressure on the latch, causing the snap hook to separate from the D-ring without the user's knowledge. This could cause an accident. The worker must take care to keep the snap hooks away from any potential causes of release. Locking snap hooks reduce the possibility of this occurrence.

   (b) Roll-out is the sudden separation of the snap-hook/D-ring combination when the snap hook is twisted in the D-ring, but the user does not deliberately open the latch. This occurs when a twist is introduced into a positioning strap with a snap-hook/D-ring combination that is incompatible. However, compatible hardware, when properly maintained, will not separate in this fashion.

6. Snap hooks shall be dimensionally compatible with the member to which they are connected so as to prevent unintentional disengagement of the connection.

   NOTE:

   (a) The possibility exists for some snap hooks to roll out of D-rings. Attachment of mismatched or multiple snap hooks to a single D-ring should be avoided. Multiple locking snap hooks may be attached to a single D-ring if they have been evaluated in the combination to be used. Locking snap hooks reduce the potential for roll-out.

   (b) Disengagement through contact of the snap hook keeper with the connected member may be prevented by the use of a locking snap hook.

   (c) Hardware compatibility can be verified. Simply attach the snap hook to the D-ring, then roll the snap hook placing the latch towards the body of the D-ring. This is similar to the action that occurs when the strap is twisted. If the rivet falls beyond the edge of the inside of the D-ring, placing pressure on the latch, the hardware is not compatible, and a roll-out potential exists.

(d) Other factors may increase the potential for accidental disengagement even if the hardware is compatible (e.g., foreign objects carried on the D-rings, condition of the snap hook, the shape of the D-ring).

7. Snap hooks shall not be connected to each other.
8. One hundred percent leather positioning straps or non-locking snap hooks shall not be used.
9. Wire rope lanyards shall be used in operations where the lanyard is subject to being cut. Wire rope lanyards shall not be used in the vicinity of energized lines or equipment.

L. Fire extinguishers

In fighting fires or in the vicinity of exposed energized parts of electric supply systems, employees shall use fire extinguishers or materials that are suitable for the purpose. If this is not possible, all adjacent and affected equipment should first be de-energized.

M. Machines or moving parts

Employees working on normally moving parts of remotely controlled equipment shall be protected against accidental starting by proper tags installed on the starting devices, or by locking or blocking where practical. Employees shall, before starting any work, satisfy themselves that these protective devices have been installed. When working or in the vicinity of automatically or remotely operated equipment such as circuit breakers that may operate suddenly, employees shall avoid being in a position where they might be injured from such operation.

N. Fuses

When fuses must be installed or removed with one or both terminals energized, employees shall use special tools or gloves insulated for the voltage involved. When installing expulsion-type fuses, employees shall wear personal eye protection and take precautions to stand clear of the exhaust path of the fuse barrel.

O. Cable reels

Cable reels shall be securely blocked so they cannot roll or rotate accidentally.

P. Street and area lighting

1. The lowering rope or chain, its supports, and fastenings shall be examined periodically.
2. A suitable device shall be provided by which each lamp on series-lighting circuits of more than 300 V may be safely disconnected from the circuit before the lamp is handled.

   EXCEPTION: This rule does not apply where the lamps are always worked on from suitable insulated platforms or aerial lift devices, or handled with suitable insulated tools, and treated as under full voltage of the circuit concerned.

Q. Antennas

Employees working in the vicinity of antennas operating in the range of 3 kHz to 300 GHz shall use controls to mitigate exposure to radio-frequency sources that exceeds permissible exposure levels at the work station.

NOTE: See Rule 410A6.

421. General operating routines

A. Duties of a first-level supervisor or person in charge

This individual shall:

1. Adopt such precautions as are within the individual's authority to prevent accidents.
2. See that the safety rules and operating procedures are observed by the employees under the direction of this individual.
3. Make all the necessary records and reports, as required.
4. Prevent unauthorized persons from approaching places where work is being done, as far as practical.

5. Prohibit the use of tools or devices unsuited to the work at hand or that have not been tested or inspected as required.

6. Conduct a job briefing with the employees involved before beginning each job. A job briefing should include at least the following items: work procedures, personal protective equipment requirements, energy source controls, hazards associated with the job, and special precautions.

B. Area protection

1. Areas accessible to vehicular and pedestrian traffic

a. Before engaging in work that may endanger the public, safety signs or traffic control devices, or both, shall be placed conspicuously to alert approaching traffic. Where further protection is needed, suitable barrier guards shall be erected. Where the nature of work and traffic requires it, a person shall be stationed to warn traffic while the hazard exists.

b. When openings or obstructions in the street, sidewalk, walkways, or on private property are being worked on or left unattended during the day, danger signals, such as safety signs and flags, shall be effectively displayed. Under these same conditions at night, warning lights shall be prominently displayed and excavations shall be enclosed with protective barricades.

2. Areas accessible to employees only

a. If the work exposes energized or moving parts that are normally protected, safety signs shall be displayed. Suitable barricades shall be erected to restrict other personnel from entering the area.

b. When working in one section where there is a multiplicity of such sections, such as one panel of a switchboard, one compartment of several, or one portion of a substation, employees shall mark the work area conspicuously and place barriers to prevent accidental contact with energized parts in that section or adjacent sections.

3. Locations with crossed or fallen wires

An employee, finding crossed or fallen wires that are creating, or may create, a hazard, shall remain on guard or adopt other adequate means to prevent accidents. The proper authority shall be notified. If the employee is qualified, and can observe the rules for safely handling energized parts by the use of insulating equipment, this employee may correct the condition.

C. Escort

Persons accompanying nonqualified employees or visitors or in the vicinity of electric equipment or lines shall be qualified to safeguard the people in their care, and see that the safety rules are observed.

422. Overhead line operating procedures

Employees performing work on or associated with overhead lines shall observe the following rules in addition to applicable rules contained elsewhere in Sections 43 and 44.

A. Setting, moving, or removing poles in or in the vicinity of energized electric supply lines

1. When setting, moving, or removing poles in or in the vicinity of energized lines, precautions shall be taken to avoid direct contact of the pole with the energized conductors. Employees shall wear suitable insulating gloves or use other suitable means when handling poles where energized conductors can be contacted. Employees performing such work shall not contact the pole with uninsulated parts of their bodies.

2. Contact with trucks, or other equipment that is being used to set, move, or remove poles in or in the vicinity of energized lines shall be avoided by employees standing on the ground or in contact with grounded objects unless employees are wearing suitable protective equipment.

B. Checking structures before climbing

1. Before climbing poles, ladders, scaffolds, or other elevated structures, employees shall determine, to the extent practical, that the structures are capable of sustaining the additional or unbalanced stresses to which they will be subjected.

2. Where there are indications that poles and structures may be unsafe for climbing, they shall not be climbed until made safe by guying, bracing, or other means.

C. Installing and removing wires or cables

1. Precautions shall be taken to prevent wires or cables that are being installed or removed from contacting energized wires or equipment. Wires or cables that are not bonded to an effective ground and which are being installed or removed in the vicinity of energized conductors shall be considered as being energized.

2. Sag of wire or cables being installed or removed shall be controlled to prevent danger to pedestrian and vehicular traffic.

3. Before installing or removing wires or cables, the strains to which poles and structures will be subjected shall be considered and necessary action taken to prevent failure of supporting structures.

4. Employees should avoid contact with moving winch lines, especially in the vicinity of sheaves, blocks, and take-up drums.

5. Employees working on or in the vicinity of equipment or lines exposed to voltages higher than those guarded against by the safety appliances provided shall take steps to be assured that the equipment or lines on which the employees are working are free from dangerous leakage or induction or have been effectively grounded.

423. Underground line operating procedures

Employees working on or with underground lines shall observe the following rules in addition to applicable rules contained elsewhere in Sections 43 and 44.

A. Guarding manhole and street openings

When covers of manholes, handholes, or vaults are removed, the opening shall be promptly protected with a barrier, temporary cover, or other suitable guard.

B. Testing for gas in manholes and unventilated vaults

1. The atmosphere shall be tested for combustible or flammable gas(es) before entry.

2. Where combustible or flammable gas(es) are detected, the work area shall be ventilated and made safe before entry.

3. Unless forced continuous ventilation is provided, a test shall also be made for oxygen deficiency.

4. Provision shall be made for an adequate continuous supply of air.

NOTE: The term *adequate* includes evaluation of both the quantity and quality of the air.

C. Flames

1. Employees shall not smoke in manholes.

2. Where open flames must be used in manholes or vaults, extra precautions shall be taken to ensure adequate ventilation.

3. Before using open flames in an excavation in areas where combustible gases or liquids may be present, such as in the vicinity of gasoline service stations, the atmosphere of the excavation shall be tested and found safe or cleared of the combustible gases or liquids.

4. When a torch or open flame is used (as in heat shrink splicing) in proximity to a visibly exposed gas or other line(s) that transport flammable material, adequate air space or a barrier shall be provided to protect the gas or line(s) that transport flammable material from the heat source.

D. Excavation

1. Cables and other buried utilities in the immediate vicinity shall be located, to the extent practical, prior to excavating.
2. When using guided boring or directional drilling methods, existing utilities should be exposed by the personnel performing the boring operation where the bore path crosses such facilities.

   NOTE: See IEEE Std 1333™-1994 [B54].
3. Hand tools used for excavating in the vicinity of energized supply cables shall be equipped with handles made of nonconductive material.

   NOTE: See IEEE Std 1333-1994 [B54].
4. Mechanized equipment should not be used to excavate in close proximity to cables and other buried utilities.
5. If a gas or line that transports flammable material is broken or damaged, employees shall:
   a. Leave the excavation open
   b. Where practical and safe, eliminate recognized ignition sources that could ignite the escaping gas or fuel
   c. Notify the proper authority
   d. Keep the public away until the condition is under control
6. When a worker is required to perform tasks in trenches or excavations where a cave-in hazard exists or the trench or excavation is in excess of 1.5 m (5 ft) in depth, shoring, sloping, or shielding methods shall be used to provide employee protection.

E. Identification

1. When underground facilities are exposed, they should be identified and shall be protected as necessary to avoid damage.
2. Where multiple cables exist in an excavation, cables other than the one being worked on shall be protected as necessary.
3. Before cutting into a cable or opening a splice, the cable should be identified and verified to be the proper cable.
4. When multiple cables exist in an excavation, the cable to be worked on shall be positively identified.

F. Operation of power-driven equipment

Employees should avoid being in manholes where power-driven rodding equipment is in operation.

Section 43.
Additional rules for communications employees

430. General

Communications employees shall observe the following rules in addition to the rules contained in Section 42.

431. Approach to energized conductors or parts

A. No employee shall approach, or bring any conductive object, within the distances to any exposed energized part as listed in Table 431-1. When repairing storm damage to communication lines that are joint use with electric supply lines at that or another point, employees shall:

   1. Treat all such supply and communication lines as energized to the highest voltage to which they are exposed, or

   2. Assure themselves that the supply lines involved are de-energized and grounded in accordance with Section 44.

B. Altitude correction

   The distances in Table 431-1 shall be used at elevations below 3600 m (12 000 ft). Altitude correction factors as indicated in Table 441-3 shall be applied above that altitude. Altitude correction factors shall be applied only to the electrical component of the minimum approach distance.

C. When repairing underground communication lines that are joint use with damaged electric supply cables, employees shall:

   1. Treat all such supply and communication lines as energized to the highest voltage to which they are exposed, or

   2. Assure that the supply lines involved are de-energized and grounded in accordance with Section 44.

(m)

Table 431-1—Communication work minimum approach distances③ ④

(See Rule 431 in its entirety.)

Voltage range phase-to-phase (rms)①	Distance to employee at altitudes from sea level to 3600 m		
0 to 50 V②	Not specified		
51 to 300 V②	Avoid contact		
301 to 750 V②	0.32 m		
751 V to 15 kV	0.69 m		
15.1 kV to 36 kV	0.91 m		
36.1 kV to 46 kV	1.07 m		
46.1 kV to 72.5 kV	1.22 m		
Voltage phase-to-phase (rms)①	**At altitudes from**		
	Sea level to 900 m	**901 m to 1800 m**	**1801 m to 3600 m**
72.6 kV to 121.0 kV	1.43 m	1.52 m	1.77 m
121.1 kV to 145.0 kV	1.60 m	1.71 m	2.01 m
145.1 kV to 169 kV	1.78 m	1.89 m	2.35 m
169.1 kV to 242 kV	2.29 m	2.47 m	2.93 m
242.1 kV to 362 kV	3.70 m	3.96 m	4.75 m
362.1 kV to 420 kV	4.55 m	4.91 m	5.82 m
420.1 kV to 550 kV	5.38 m	5.79 m	6.89 m
550.1 kV to 800 kV	7.19 m	7.74 m	9.23 m

①For single-phase lines off three-phase systems, use the phase-to-phase voltage of that system.
②For single-phase systems, use the highest voltage available.
③Distances listed are for standard atmospheric conditions defined as temperatures above freezing, wind less than 24 km per h, and normal barometric pressure with unsaturated and uncontaminated air.
④The basis for the MAD values in this table was obtained from OSHA 29 CFR 1910.269 Tables R-3 through R-7. Below 72 kV, the MAD values for phase-to-phase exposure of Table R-6 were used. Above 72 kV, the values for phase-to-ground exposure of Table R-7 were used. An additional 0.3 m was added for communications workers over the electrical worker value.

(ft)

Table 431-1—Communication work minimum approach distances[③] [④]

(See Rule 431 in its entirety.)

Voltage range phase-to-phase (rms)[①]	Distance to employee at altitudes from sea level to 12 000 ft		
0 to 50 V[②]	Not specified		
51 to 300 V[②]	Avoid contact		
301 to 750 V[②]	1 ft-1 in		
751 V to 15 kV	2 ft-3 in		
15.1 kV to 36 kV	3 ft-0 in		
36.1 kV to 46 kV	3 ft-6 in		
46.1 kV to 72.5 kV	4 ft-0 in		
Voltage range phase-to-phase (rms)[①]	**At altitudes from**		
	Sea level to 3000 ft	**3001 ft to 6000 ft**	**6001 ft to 12 000 ft**
72.6 kV to 121.0 kV	4 ft-9 in	5 ft-0 in	5 ft-10 in
121.1 kV to 145.0 kV	5 ft-4 in	5 ft-8 in	6 ft-8 in
145.1 kV to 169 kV	5 ft-10 in	6 ft-3 in	7 ft-3 in
169.1 kV to 242 kV	7 ft-8 in	8 ft-2 in	9 ft-8 in
242.1 kV to 362 kV	12 ft-3 in	13 ft-2 in	15 ft-8 in
362.1 kV to 420 kV	14 ft-11 in	16 ft-2 in	19 ft-2 in
420.1 kV to 550 kV	17 ft-8 in	19 ft-0 in	22 ft-8 in
550.1 kV to 800 kV	23 ft-8 in	25 ft-5 in	30 ft-4 in

①For single-phase lines off three-phase systems, use the phase-to-phase voltage of that system.
②For single-phase systems, use the highest voltage available.
③Distances listed are for standard atmospheric conditions defined as temperatures above freezing, wind less than 15 mi per h, and normal barometric pressure with unsaturated and uncontaminated air.
④ The basis for the MAD values in this table was obtained from OSHA 29 CFR 1910.269 Tables R-3 through R-7. Below 72 kV, the MAD values for phase-to-phase exposure of Table R-6 were used. Above 72 kV, the values for phase-to-ground exposure of Table R-7 were used. An additional 1 ft was added for communications workers over the electrical worker value.

432. Joint-use structures

When working on jointly used poles or structures, employees shall not approach closer than distances specified in Table 431-1 and shall not position themselves above the level of the lowest electric supply conductor or equipment exclusive of vertical runs, street lighting, and supply equipment mounted below communications space that meets the clearance requirements listed in Rule 238B.

NOTE: Examples of supply equipment mounted below the communication space include electronic controls, photovoltaic panels, etc.

EXCEPTION: On voltages 140 kV and below, this rule does not apply where communications facilities are attached above electric supply conductors if a rigid fixed barrier has been installed between the supply and communications facilities.

433. Attendant on surface at joint-use manhole

While personnel are in a joint-use manhole, an employee shall be available on the surface in the immediate vicinity to render assistance as may be required.

434. Sheath continuity

Metallic or semiconductive sheath continuity shall be maintained by bonding across the opening, or by equivalent means, when working on buried cable or on cable in manholes.

Section 44.
Additional rules for supply employees

440. General

Supply employees shall observe the following rules in addition to the rules contained in Section 42.

441. Energized conductors or parts

A. Minimum approach distance to energized lines or parts

1. General

Employees shall not approach or bring any conductive object within the minimum approach distance listed in Table 441-1 or Table 441-5 to exposed energized lines or parts unless one of the following is met:

a. The line or part is de-energized and grounded per Rule 444D.

EXCEPTION: For voltages less than 600 V where the making of the ground is impractical, the line or part may be isolated in lieu of installing temporary protective grounds provided the following conditions are met: (a) the lines and equipment are isolated from all sources and tested to be de-energized, (b) there is no possibility of contact with another energized source, and (c) the hazard of induced voltage is not present.

b. The employee is insulated from the energized line or part. Electrical protective equipment insulated for the voltage involved, such as tools, rubber gloves, or rubber gloves with sleeves, shall be considered effective insulation for the employee from the energized line or part being worked on.

c. The energized line or part is insulated from the employee and from any other line or part at a different voltage.

d. The employee is performing barehand live-line work according to Rule 446.

NOTE 1: Minimum approach distances calculated under this rule for 0.301 kV to 0.750 kV contain the electrical component plus 0.31 m (1 ft) for inadvertent movement. Voltages 0.751 kV to 72.5 kV contain the electrical component plus 0.61 m (2 ft) for inadvertent movement. Voltages above 72.5 kV contain the electrical component plus 0.31 m (1 ft) for inadvertent movement.

NOTE 2: Methodology for calculating minimum approach distances were taken from OSHA 29 CFR 1910.269 Appendix B [B68].

NOTE 3: The voltage ranges are contained in ANSI C84.1-1995, Table 1.

NOTE 4: For the purpose of Section 44, *reach* is defined as the range of anticipated motion of an employee while performing a task, and *extended reach* is defined as the range of anticipated motion of a conductive object being held by an employee while performing a task.

2. Precautions for approach—Voltages from 51 V to 300 V

Employees shall not contact exposed energized parts operating at 51 V to 300 V, unless the provisions of Rule 441A1 are met.

3. Precautions for approach—Voltages from 301 V to 72.5 kV

At voltages from 301 V to 72.5 kV, employees shall be protected from phase-to-phase and phase-to-ground differences in voltage. See Table 441-1 or Table 441-5 for the minimum approach distances to live parts.

a. When exposed grounded lines, conductors, or parts are in the work area, they shall be guarded or insulated.

EXCEPTION: When work is being performed on parts energized between 300 V and 750 V within equipment enclosures, (e.g., control panels and relay cabinets), insulating or guarding of all exposed grounded lines, conductors, or parts in the work area is not required provided that employees use insulated tools and/or gloves and that exposed grounded lines, conductors, and parts are covered to the extent feasible.

b. Rubber insulating gloves, insulated for the maximum use voltage as listed in Table 441-7, shall be worn whenever employee's working position is within the reach or extended reach of the minimum approach distances listed in Table 441-1 or Table 441-5, except as permitted by Rule 441A1c.

c. When using the Rubber Glove Work Method, rubber gloves shall be supplemented by one of the following two protective methods:

(1) The employee shall wear rubber insulating sleeves, insulated for the maximum use voltage as listed in Table 441-7, in addition to the rubber insulating gloves.

EXCEPTION: When work is performed on electric supply equipment energized at 750 V or less, rubber sleeves are not required if only the live parts being worked on are exposed.

(2) All exposed energized lines or parts, other than those temporarily exposed to perform work and maintained under positive control, located within the reach or extended reach of the employee's work position, shall be covered with insulating protective equipment.

d. When the Rubber Glove Work Method is employed at voltages above 15 kV phase-to-phase, supplementary insulation (e.g., insulated aerial device or structure-mounted insulating work platform), tested for the voltage involved shall be used to support the worker.

e. Cover-up equipment used to insulate phase-to-phase exposure shall be rated for not less than the phase-to-phase voltage of the circuit(s) in the work area. All other cover-up equipment shall be rated for not less than the phase-to-ground voltage of the circuit(s). The determination of whether phase-to-phase or phase-to-ground exposure exists shall be based on factors such as but not limited to: work rules, conductor spacing, worker position, and task being performed.

f. Cover-up equipment, when used, shall be applied to the exposed facilities as the employee first approaches the facilities from any direction, be that from the structure or from an aerial device, and shall be removed in the reverse order. This protective cover-up shall extend beyond the reach of the employee's anticipated work position or extended reach distance.

4. Precautions for approach—Voltages above 72.5 kV

When performing live line work, employees shall position themselves so that they are not within the reach or extended reach of the applicable minimum approach distance.

In lieu of using the minimum approach distances in Table 441-1, the minimum approach distance in Table 441-2 through Table 441-4 may be used provided the per unit transient overvoltage value (T) has been determined through an engineering analysis considering the system design, expected operating conditions, and control measures.

NOTE 1: Control measures include blocking reclosing, prohibiting switching during live line work, using protective air gaps, use of closing resistors and surge arrestors, etc.

NOTE 2: IEEE Std 516-2009 and OSHA 29 CFR 1910.269 Appendix B [B68] contain information that may be used to perform an engineering analysis to determine maximum transient overvoltage factors. The engineering analysis may be performed on a system basis or a per-line basis.

5. Temporary (transient) overvoltage control device (TTOCD)

TTOCD, which are designed and tested for installation adjacent to the worksite to limit the TOV at the worksite, may be used to obtain a lower value of T.

An engineering analysis, including laboratory testing, of the TTOCD shall be performed to determine and identify the range of sparkover voltages. The withstand and sparkover characteristics of a TTOCD are determined by sparkover probability data for the particular protective gap geometry, gap distance, and conductor bundle geometry. The TOV rating for the TTOCD device shall be determined from test data and shall be the voltage at which the device sparks over 50% of the time. The T_{TTOCD} is calculated by dividing the TOV rating of the device by nominal peak voltage rounded-up to one decimal place.

As an example of determining T_{TTOCD}, for a line operating at 345 kV, using TTOCD which has been installed adjacent to the worksite to limit the maximum worksite T_{TTOCD}, having a TOV rating of 510 kV:

$T_{TTOCD} = 510 / ((362 \cdot 1.414) / 1.732)$

$T_{TTOCD} = 510 / 295.53 = 1.72$ or 1.8

6. Altitude correction

The distances in Table 441-1 through Table 441-5 shall be used at elevations below 900 m (3000 ft). Above that elevation, the minimum approach distance shall be increased by:

a. Multiplying the electrical component of the minimum approach distance by the applicable altitude correction factors of Table 441-6, and

b. Adding the result to the values for inadvertent movement values as follows:

0.301 kV to 0.750 kV= 0.31 m (1 ft)

0.751 kV to 72.5 kV = 0.61 m (2 ft)

72.6 kV to 800 kV = 0.31 m (1 ft)

NOTE: The electrical component of clearance included in Table 441-1 through Table 441-5 is the table value less the value for inadvertent movement for that voltage.

B. Additional approach requirements

1. The clear insulation distance associated with insulators shall be the shortest straight-line air-gap distance from the nearest energized part to the nearest grounded part.

2. When working on insulators under live work procedures employing rubber gloves or live-line tools, the clear insulation distance shall be not less than the straight-line distance with tools required by Rule 441A4.

3. Work may be performed at the grounded end of an open switch if all of the following conditions are met:

a. The air-gap distance of the switch shall not be reduced in any manner. This distance shall be not less than the minimum approach distances determined by Rules 441A2, 441A3, and 441A4 less the inadvertent movement values.

b. The employee shall maintain the minimum approach distance to the energized part of the switch as required by Rules 441A2, 441A3, and 441A4.

4. Special rules for working on insulator assemblies operating above 72.5 kV

a. When work is to be performed at the ground end of an insulator assembly, the minimum approach distance to the nearest energized part may equal the straight-line distance measured along the insulators.

b. For suspension insulator assembly installations (see ANSI C29.2) operating above 72.5 kV (ac), the first insulator at the grounded end may be temporarily shorted out as part of the work procedure. Before temporarily shorting out any insulator units, as part of the work procedure, each of the insulator units in the string shall be tested to determine the number and location of any failed units.

EXCEPTION: For voltages at 230 kV (ac) and above, up to three insulator units may be temporarily shorted out as part of the work procedure, provided that the minimum approach distance requirements of Rule 441A4 are met.

c. When performing live work employing the barehand technique on installations operating above 72.5 kV (ac), the first insulator at the energized (hot) end of a suspension insulator assembly (see ANSI C29.2) may be shorted out during the work. Before temporarily shorting out any insulator units, as part of the work procedure, each of the insulator units in the string shall be tested to determine the number and location of any failed units.

EXCEPTION: For voltages at 230 kV (ac) and above, up to three insulator units may be temporarily shorted out as part of the work procedure, provided that the minimum approach distance requirements of Rule 441A4 are met.

(1) The minimum approach distance to the grounded end of the insulator assembly may be equal to the straight-line distance from the nearest energized part to the closest grounded part across the insulators.

(2) The straight-line insulation distance shall be not less than the values required by Rule 441A4.

C. Live-line tool clear insulation length

1. Clear live-line tool length

The clear live-line tool distance shall be not less than the distance measured longitudinally along the live-line tool from the conductive part at the working end of the tool and any part of the employee. Distances for conducting sections (such as metallic splices and hardware) shall be subtracted from the clear live-line length. The clear live-line tool length shall equal or exceed the values for the minimum approach distance with tools required by Rule 441A4 for the indicated voltage ranges. The minimum clear live-line tool distance shall be the distance measured longitudinally along the live-line tool from the conductive part at the working end of the tool to any part of the employee.

2. Live-line conductor support tool length

Conductor support tools such as link sticks, strain carriers, and insulator cradles may be used provided that the clear insulating distance is at least as long as the insulator string or the maximum distance specified in Rule 441A4. When installing this equipment, the employee shall maintain the minimum approach distance required equal to the clear insulating length for the support tools.

NOTE: Conductive components of tools disturb the field in the gap and decrease the insulation value of the tool more than the linear subtraction of the length(s) of the conductive components.

Table 441-1—AC live work minimum approach distance ④

(See Rule 441 in its entirety.)

Voltage in kilovolts phase-to- phase① ② ③	Distance to employee④			
	Phase-to-ground		Phase-to-phase	
	(m)	(ft-in)	(m)	(ft-in)
0 to 0.050	Not specified		Not specified	
0.051 to 0.300	Avoid contact		Avoid contact	
0.301 to 0.750	0.33	1-1	0.33	1-1
0.751 to 5.0	0.63	2-1	0.63	2-1
5.1 to 15.0	0.65	2-2	0.68	2-3
15.1 to 36.0	0.77	2-7	0.89	3-0
36.1 to 46.0	0.84	2-10	0.98	3-3
46.1 to 72.5	1.00	3-4	1.20	4-0

Voltage in kilovolts phase-to-phase	Distance to employee from energized part ④ ⑤ ⑥ ⑩					
	Without tools phase-to-ground		With tools phase-to-ground⑦ ⑨		Without tools phase-to-phase⑧	
	(m)	(ft-in)	(m)	(ft-in)	(m)	(ft-in)
72.6 to 121	1.06	3-6	1.13	3-9	1.42	4-8
121.1 to 145	1.21	4.0	1.30	4-4	1.64	5-5
145.1 to 169	1.36	4-6	1.46	4-10	1.94	6-5
169.1 to 242	1.87	6-2	2.01	6-8	3.08	10-2
242.1 to 362	3.19	10-6	3.41	11-3	5.52	18-2
362.1 to 420	3.99	13.2	4.25	14-0	6.81	22-5
420.1 to 550	4.78	15-9	5.07	16-8	8.24	27-1
550.1 to 800	6.53	21-6	6.88	22-7	11.38	37-5

①For single-phase lines off three-phase systems, use the phase-to-phase voltage of that system.
②For single-phase systems, use the highest voltage available.
③Inadvertent movement factors used in these tables are as follows:
0.301 kV to 0.750 kV = 0.31 m (1 ft)
0.751 kV to 72.5 kV = 0.61 m (2 ft)
72.6 kV to 800 kV = 0.31 m (1 ft)
④Distances listed are for standard atmospheric conditions defined as temperatures above freezing, wind less than 15 mi per h or 24 km per h, unsaturated air, normal barometer, uncontaminated air, and clean and dry insulators.
⑤For voltages above 72.5 kV, distances are based on altitudes below 900 m (3000 ft) above sea level. For altitudes above 900 m (3000 ft), Rule 441A6 applies.

⑥Distances were calculated using the following TOV values:
72.6 kV to 362 kV = 3.5
362.1 kV to 550 kV = 3.0
550.1 kV to 800 kV = 2.5
⑦Distances for live-line tools in the air gap were calculated by adding a tool factor to the electrical component (OSHA 29 CFR 1910.269 Appendix B [B68]).
⑧Phase-to-phase live-line tool in the air gap values are not available. If this situation exists, an engineering evaluation should be performed.
⑨*With tools* means a live-line tool bridging the air gap to the employee from the energized part.
⑩For barehand work where the employee is at line potential, this distance is to an object at a different potential.

(m)

Table 441-2—AC live work minimum approach distances for altitudes less than 900 m above sea level, where T has been determined according to Rule 441A4

Maximum anticipated per unit overvoltage factor T	Distance to employee—phase-to-ground work without tools (m)							
	Maximum phase-to-phase voltage in kV							
	72.6 to 121.0	121.1 to 145.0	145.1 to 169.0	169.1 to 242.0	242.1 to 362.0	362.1 to 420.0	420.1 to 550.0	550.1 to 800.0
1.5	0.63	0.70	0.76	0.95	1.27	1.42	1.81	2.95
1.6	0.66	0.72	0.79	1.00	1.33	1.50	1.96	3.24
1.7	0.68	0.75	0.82	1.04	1.40	1.57	2.11	3.54
1.8	0.70	0.77	0.85	1.08	1.46	1.65	2.27	3.86
1.9	0.72	0.80	0.88	1.12	1.53	1.74	2.44	4.20
2.0	0.74	0.83	0.91	1.17	1.59	1.85	2.61	4.55
2.1	0.76	0.85	0.94	1.21	1.65	1.96	2.80	4.92
2.2	0.78	0.88	0.97	1.25	1.73	2.08	2.99	5.30
2.3	0.80	0.90	1.00	1.29	1.83	2.20	3.18	5.70
2.4	0.83	0.93	1.03	1.34	1.93	2.33	3.39	6.11
2.5	0.85	0.95	1.06	1.38	2.03	2.46	3.60	6.53
2.6	0.87	0.98	1.09	1.42	2.13	2.59	3.82	
2.7	0.89	1.00	1.12	1.46	2.24	2.73	4.05	
2.8	0.91	1.03	1.15	1.51	2.34	2.87	4.29	
2.9	0.93	1.05	1.18	1.55	2.46	3.01	4.53	
3.0	0.95	1.08	1.21	1.59	2.57	3.16	4.78	
3.1	0.98	1.11	1.24	1.64	2.69	3.32		
3.2	1.00	1.13	1.27	1.68	2.81	3.48		
3.3	1.02	1.16	1.30	1.74	2.93	3.65		
3.4	1.04	1.18	1.33	1.80	3.06	3.81		
3.5	1.06	1.21	1.36	1.87	3.19	3.99		

(ft)

Table 441-2— AC live work minimum approach distances for altitudes less than 3000 ft above sea level, where T has been determined according to Rule 441A4

Maximum anticipated per unit overvoltage factor T	Distance to employee—phase-to-ground work without tools (ft-in)							
	Maximum phase-to-phase voltage in kV							
	72.6 to 121.0	121.1 to 145.0	145.1 to 169.0	169.1 to 242.0	242.1 to 362.0	362.1 to 420.0	420.1 to 550.0	550.1 to 800.0
1.5	2-1	2-4	2-6	3-2	4-3	4-8	6-0	9-9
1.6	2-2	2-5	2-8	3-4	4-5	5-0	6-6	10-8
1.7	2-3	2-6	2-9	3-5	4-8	5-2	7-0	11-8
1.8	2-4	2-7	2-10	3-7	4-10	5-5	7-6	12-8
1.9	2-5	2-8	2-11	3-9	5-1	5-9	8-1	13-10
2.0	2-6	2-9	3-0	3-11	5-3	6-1	8-7	15-0
2.1	2-6	2-10	3-2	4-0	5-5	6-6	9-3	16-2
2.2	2-7	2-11	3-3	4-2	5-9	6-10	9-10	17-5
2.3	2-8	3-0	3-4	4-3	6-1	7-3	10-6	18-9
2.4	2-9	3-1	3-5	4-5	6-4	7-8	11-2	20-1
2.5	2-10	3-2	3-6	4-7	6-8	8-1	11-10	21-6
2.6	2-11	3-3	3-7	4-8	7-0	8-6	12-7	
2.7	3-0	3-4	3-9	4-10	7-5	9-0	13-4	
2.8	3-0	3-5	3-10	5-0	7-9	9-5	14-1	
2.9	3-1	3-6	3-11	5-2	8-1	9-11	14-11	
3.0	3-2	3-7	4-0	5-3	8-6	10-5	15-9	
3.1	3-3	3-8	4-1	5-5	8-10	10-11		
3.2	3-4	3-9	4-3	5-7	9-3	11-6		
3.3	3-5	3-10	4-4	5-9	9-8	12-0		
3.4	3-5	3-11	4-5	5-11	10-1	12-7		
3.5	3-6	4-0	4-6	6-2	10-6	13-2		

(m)

Table 441-3— AC live work minimum approach distances for altitudes less than 900 m above sea level, where T has been determined according to Rule 441A4

Maximum anticipated per unit overvoltage factor T	Distance to employee—phase-to-ground work with tools (m)							
	Maximum phase-to-phase voltage in kV							
	72.6 to 121.0	121.1 to 145.0	145.1 to 169.0	169.1 to 242.0	242.1 to 362.0	362.1 to 420.0	420.1 to 550.0	550.1 to 800.0
1.5	0.67	0.74	0.81	1.02	1.37	1.53	1.95	3.16
1.6	0.69	0.76	0.84	1.06	1.44	1.62	2.11	3.46
1.7	0.71	0.79	0.87	1.11	1.51	1.70	2.28	3.78
1.8	0.74	0.82	0.90	1.16	1.58	1.78	2.45	4.12
1.9	0.76	0.85	0.94	1.21	1.65	1.88	2.62	4.47
2.0	0.78	0.88	0.97	1.25	1.72	1.99	2.81	4.83
2.1	0.81	0.90	1.00	1.30	1.79	2.12	3.00	5.21
2.2	0.83	0.93	1.03	1.35	1.87	2.24	3.20	5.61
2.3	0.85	0.96	1.07	1.39	1.97	2.37	3.40	6.02
2.4	0.88	0.99	1.10	1.44	2.08	2.50	3.62	6.44
2.5	0.90	1.02	1.13	1.49	2.19	2.64	3.84	6.88
2.6	0.92	1.04	1.17	1.53	2.29	2.78	4.07	
2.7	0.95	1.07	1.20	1.58	2.41	2.93	4.31	
2.8	0.97	1.10	1.23	1.63	2.52	3.07	4.56	
2.9	0.99	1.13	1.26	1.67	2.64	3.23	4.81	
3.0	1.02	1.16	1.30	1.72	2.76	3.38	5.07	
3.1	1.04	1.19	1.33	1.77	2.88	3.55		
3.2	1.06	1.21	1.36	1.81	3.01	3.72		
3.3	1.09	1.24	1.39	1.88	3.14	3.89		
3.4	1.11	1.27	1.43	1.95	3.27	4.07		
3.5	1.13	1.30	1.46	2.01	3.41	4.25		

(ft)

Table 441-3— AC live work minimum approach distances for altitudes less than 3000 ft above sea level, where T has been determined according to Rule 441A4

Maximum anticipated per unit overvoltage factor T	Distance to employee—phase-to-ground work with tools (ft-in)							
	Maximum phase-to-phase voltage in kV							
	72.6 to 121.0	121.1 to 145.0	145.1 to 169.0	169.1 to 242.0	242.1 to 362.0	362.1 to 420.0	420.1 to 550.0	550.1 to 800.0
1.5	2-3	2-6	2-8	3-5	4-6	5-1	6-5	10-5
1.6	2-4	2-6	2-10	3-6	4-9	5-4	7-0	11-5
1.7	2-4	2-8	2-11	3-8	5-0	5-7	7-6	12-5
1.8	2-6	2-9	3-0	3-10	5-3	5-11	8-1	13-7
1.9	2-6	2-10	3-2	4-0	5-5	6-3	8-8	14-8
2.0	2-7	2-11	3-3	4-2	5-8	6-7	9-3	15-11
2.1	2-8	3-0	3-4	4-4	5-11	7-0	9-11	17-2
2.2	2-9	3-1	3-5	4-6	6-2	7-5	10-6	18-5
2.3	2-10	3-2	3-7	4-7	6-6	7-10	11-2	19-10
2.4	2-11	3-3	3-8	4-9	6-10	8-3	11-11	21-2
2.5	3-0	3-5	3-9	4-11	7-3	8-8	12-8	22-7
2.6	3-1	3-5	3-11	5-1	7-7	9-2	13-5	
2.7	3-2	3-7	4-0	5-3	7-11	9-8	14-2	
2.8	3-3	3-8	4-1	5-5	8-4	10-1	15-0	
2.9	3-3	3-9	4-2	5-6	8-8	10-8	15-10	
3.0	3-5	3-10	4-4	5-8	9-1	11-2	16-8	
3.1	3-5	3-11	4-5	5-10	9-6	11-8		
3.2	3-6	4-0	4-6	6-0	9-11	12-3		
3.3	3-7	4-1	4-7	6-3	10-4	12-10		
3.4	3-8	4-3	4-9	6-5	10-9	13-5		
3.5	3-9	4-4	4-10	6-8	11-3	4-0		

(m)

Table 441-4— AC live work minimum approach distances for altitudes less than 900 m above sea level, where T has been determined according to Rule 441A4

Maximum anticipated per unit overvoltage factor T	Distance to employee—phase-to-phase work, in air, barehand (m)							
	Maximum phase-to-phase voltage in kV							
	72.6 to 121.0	121.1 to 145.0	145.1 to 169.0	169.1 to 242.0	242.1 to 362.0	362.1 to 420.0	420.1 to 550.0	550.1 to 800.0
1.5	0.84	0.95	1.05	1.37	1.99	2.40	3.46	5.97
1.6	0.87	0.98	1.09	1.43	2.13	2.58	3.73	6.43
1.7	0.90	1.02	1.13	1.48	2.27	2.75	4.02	6.92
1.8	0.93	1.05	1.17	1.54	2.41	2.94	4.31	7.42
1.9	0.96	1.08	1.21	1.60	2.56	3.13	4.61	7.93
2.0	0.99	1.12	1.25	1.66	2.71	3.33	4.92	8.47
2.1	1.01	1.15	1.29	1.73	2.87	3.53	5.25	9.02
2.2	1.04	1.19	1.33	1.81	3.03	3.74	5.55	9.58
2.3	1.07	1.22	1.37	1.90	3.20	3.95	5.86	10.16
2.4	1.10	1.26	1.41	1.99	3.37	4.17	6.18	10.76
2.5	1.13	1.29	1.45	2.08	3.55	4.40	6.50	11.38
2.6	1.16	1.33	1.49	2.17	3.73	4.63	6.83	
2.7	1.19	1.36	1.53	2.26	3.91	4.87	7.18	
2.8	1.22	1.39	1.57	2.36	4.10	5.11	7.52	
2.9	1.24	1.43	1.61	2.45	4.29	5.36	7.88	
3.0	1.27	1.46	1.65	2.55	4.49	5.59	8.24	
3.1	1.30	1.50	1.70	2.65	4.69	5.82		
3.2	1.33	1.53	1.76	2.76	4.90	6.07		
3.3	1.36	1.57	1.82	2.86	5.11	6.31		
3.4	1.39	1.60	1.88	2.97	5.32	6.56		
3.5	1.42	1.64	1.94	3.08	5.52	6.81		

(ft)

Table 441-4—AC live work minimum approach distances for altitudes less than 3000 ft above sea level, where T has been determined according to Rule 441A4

Maximum anticipated per unit overvoltage factor T	Distance to employee—phase-to-phase work, in air, barehand (ft-in)							
	Maximum phase-to-phase voltage in kV							
	72.6 to 121.0	121.1 to 145.0	145.1 to 169.0	169.1 to 242.0	242.1 to 362.0	362.1 to 420.0	420.1 to 550.0	550.1 to 800.0
1.5	2-10	3-2	3-6	4-6	6-7	7-11	11-5	19-8
1.6	2-11	3-3	3-7	4-9	7-0	8-6	12-3	21-2
1.7	3-0	3-5	3-9	4-11	7-6	9-1	13-3	22-9
1.8	3-1	3-6	3-11	5-1	7-11	9-8	14-2	24-5
1.9	3-2	3-7	4-0	5-3	8-5	10-4	15-2	26-1
2.0	3-3	3-9	4-2	5-6	8-11	11-0	16-2	27-10
2.1	3-4	3-10	4-3	5-9	9-5	11-7	17-3	29-8
2.2	3-5	3-11	4-5	6-0	10-0	12-4	18-3	31-6
2.3	3-7	4-1	4-6	6-3	10-6	13-0	19-3	33-5
2.4	3-8	4-2	4-8	6-7	11-1	13-9	20-4	35-4
2.5	3-9	4-3	4-10	6-10	11-8	14-6	21-4	37-5
2.6	3-10	4-5	4-11	7-2	12-3	15-3	22-5	
2.7	3-11	4-6	5-1	7-5	12-10	16-0	23-7	
2.8	4-1	4-8	5-2	7-9	13-6	16-10	24-9	
2.9	4-1	4-9	5-4	8-1	14-1	17-8	25-11	
3.0	4-3	4-10	5-5	8-5	14-9	18-5	27-1	
3.1	4-4	5-0	5-7	8-9	15-5	19-2		
3.2	4-5	5-1	5-10	9-1	16-1	19-11		
3.3	4-6	5-2	6-0	9-5	16-10	20-9		
3.4	4-7	5-3	6-3	9-9	17-6	21-7		
3.5	4-8	5-5	6-5	10-2	18-2	22-5		

Table 441-5—DC live work minimum approach distance

(See Rule 441 in its entirety.)

Maximum pole-to-pole voltage in kilovolts①②③	Distance to employee			
	Pole-to-ground			
	(m)		(ft-in)	
0 to 0.050	Not specified			
0.051 to 0.300	Avoid contact			
0.301 to 0.750	0.32		1-1	
0.751 to 5	0.64		2-2	
5.1 to 72.5	0.89		2-11	
Maximum pole-to-ground voltage in kilovolts①②③	**Distance to employee from energized part**			
	Without tools pole-to-ground		**With tools④ pole-to-ground**	
	(m)	**(ft-in)**	**(m)**	**(ft-in)**
72.6 to 250	1.28	4-3	1.37	4-7
250.1 to 400	1.95	6-5	2.11	7-0
400.1 to 500	2.61	8-7	2.81	9-3
500.1 to 600	3.39	11-2	3.62	11-11
600.1 to 750	4.79	15-9	5.08	16-8

①For voltages above 72.6 kV, distances were calculated using a TOV value of 1.8.

②The data used to calculate these tables was obtained from test data taken with standard atmospheric conditions defined as temperatures above freezing, wind less than 15 mi per h or 24 km per h, unsaturated air, normal barometer, uncontaminated air, and clean and dry insulators. If standard atmospheric conditions do not exist, extra care must be taken.

③For voltages above 72.5 kV, distances are based on altitudes below 900 m (3000 ft) above sea level. For altitudes above 900 m (3000 ft), Rule 441A6 applies.

④Distances for live-line tools in the air gap were calculated by adding a tool factor to the electrical component (IEEE 516 C_2 1.1 tool factor).

Table 441-6—Altitude correction factor
(See Rule 441 in its entirety.)

Altitude		Correction factor
(m)	(ft)	
Sea level to 900	Sea level to 3000	1.00
901 to 1200	3001 to 4000	1.02
1201 to 1500	4001 to 5000	1.05
1501 to 1800	5001 to 6000	1.08
1801 to 2100	6001 to 7000	1.11
2101 to 2400	7001 to 8000	1.14
2401 to 2700	8001 to 9000	1.17
2701 to 3000	9001 to 10 000	1.20
3001 to 3600	10 001 to 12 000	1.25
3601 to 4200	12 001 to 14 000	1.30

Table 441-7—Maximum use voltage for rubber insulating equipment

Class of equipment	Maximum use voltage①
00	500
0	1000
1	7500
2	17 000
3	26 500
4	36 000

①The maximum use voltage is the ac voltage (rms) rating of the protective equipment that designates the maximum nominal design voltage of the energized system that may be safely worked. The nominal design voltage is equal to the phase-to-phase voltage on multiphase circuits.

EXCEPTION 1: If there is no multiphase exposure in a system area (at the worksite) and the voltage exposure is limited to the phase (polarity on dc systems) to ground potential, the phase (polarity on dc systems) to ground potential shall be considered to be the nominal design voltage.

EXCEPTION 2: If electric equipment and devices are insulated, isolated, or both, such that the multiphase exposure on a grounded wye circuit is removed and if supplemental insulation (e.g., insulated aerial device or structure-mounted insulating work platform) is used to insulate the employee from ground, then the nominal design voltage may be considered as the phase-to-ground voltage on that circuit.

442. Switching control procedures

A. Designated person

A designated person shall:

1. Keep informed of operating conditions affecting the safe and reliable operation of the system.
2. Maintain a suitable record showing operating changes in such conditions.
3. Issue or deny authorization for switching, as required, for safe and reliable operation.

B. Specific work

Authorization from the designated person shall be secured before work is begun on or in the vicinity of station equipment, transmission, or interconnected feeder circuits and where circuits are to be de-energized at stations. The designated person shall be notified when such work ceases.

EXCEPTION 1: In an emergency, to protect persons or property, or when communication with the designated person is difficult because of storms or other causes, any qualified employee may make repairs on or in the vicinity of the equipment or lines covered by this rule without special authorization if the qualified employee can clear the trouble promptly with available help in compliance with the remaining rules. The designated person shall thereafter be notified as soon as possible of the action taken.

EXCEPTION 2: Suspension of normal rule or rules under disaster conditions: Where catastrophic service disruptions occur (e.g., earthquake, hurricane) and where multiple employer crews may be imported to assist in service restorations, the normal use of Rule 442 procedures may be suspended provided that:

(a) Each individual involved in system repairs is informed of the suspension of normal rules.

(b) Employees are required to observe all requirements of Rules 443 and 444, including protection designated from step and touch potentials.

(c) Equipment used to de-energize or re-energize circuits at designated points of control (e.g., station breakers) is operated in conformance with Rules 442A and 442D.

(d) Tagging requirements under Rule 444C, for this *EXCEPTION*, shall include, and may be limited to, designated points of control.

C. Operations at stations

Qualified employees shall obtain authorization from the designated person before switching sections of circuits.

In the absence of specific operating schedules, employees shall secure authorization from the designated person before opening and closing supply circuits or portions thereof or starting and stopping equipment affecting system operation at stations.

EXCEPTION 1: Sections of distribution circuits are excepted if the designated person is notified as soon as possible after the action is taken.

EXCEPTION 2: In an emergency, to protect persons or property, any qualified employee may open circuits and stop moving equipment without special authorization if, in the judgment of the qualified employee, this action will promote safety, but the designated person shall be notified as soon as possible of such action, with reasons therefore.

D. Re-energizing after work

Instructions to re-energize equipment or lines that have been de-energized by permission of the designated person shall not be issued by the designated person until all employees who requested the line to be de-energized have reported clear. Employees who have requested equipment or lines de-energized for other employees or crews shall not request that equipment or lines be re-energized until all of the other employees or crews have reported clear. The same procedure shall be followed when more than one location is involved.

E. Tagging electric supply circuits associated with work activities

1. Equipment or circuits that are to be treated as de-energized and grounded per Rule 444D shall have suitable tags attached to all points where such equipment or circuits can be energized.
2. When the automatic reclosing feature of a reclosing device is disabled during the course of work on energized equipment or circuits, a tag shall be placed at the reclosing device location.

EXCEPTION: If the automatic reclosing feature of a reclosing device is disabled by a Supervisory Control and Data Acquisition System (SCADA), the system shall provide for the following:

(a) At the SCADA operating point

(1) A signal is received by the SCADA operator confirming that the disabling operation has occurred at the reclosing device location, and

(2) A readily visible tag or electronic display is used to inform any potential SCADA operator that a disabling operation has been initiated, and

(3) The tag or electronic display is removed before action is taken to re-enable the automatic reclosing feature.

(b) At the reclosing device location

(1) The reclosing feature is disabled in such a manner as to prevent manual override of the normal control by any potential on-site operator, or

(2) A signal, flag, or other display is used in such a manner as to alert any potential on-site operator that the reclosing feature has been disabled.

3. The required tags shall be placed to clearly identify the equipment or circuits on which work is being performed.

F. Restoration of service after automatic trip

1. When circuits or equipment upon which tags have been placed open automatically, the circuits or equipment shall be left open until reclosing has been authorized.

2. When circuits open automatically, local operating rules shall determine in what manner and how many times they may be closed with safety.

G. Repeating oral messages

Each employee receiving an oral message concerning the switching of lines and equipment shall immediately repeat it back to the sender and obtain the identity of the sender. Each employee sending such an oral message shall require it to be repeated back by the receiver and secure the latter's identity.

443. Work on energized lines and equipment

A. General requirements

1. When working on energized lines and equipment, one of the following safeguards shall be applied:

a. Insulate employee from energized parts

b. Isolate or insulate the employee from ground and grounded structures, and potentials other than the one being worked on

2. Employees shall not place dependence for their safety on the covering (nonrated insulation) of wires. All precautions (see Section 44) for working on energized parts shall be observed.

3. All employees working on or in the vicinity of lines or equipment exposed to voltages higher than those guarded against by the safety protective equipment provided shall assure themselves that the equipment or lines on which they are working are free from dangerous leakage or induction, or have been effectively grounded.

4. Cutting into insulating coverings of energized conductors

a. A supply cable to be worked on as de-energized that cannot be positively identified or determined to be de-energized shall be pierced or severed at the work location with a tool designed for the purpose.

b. Before cutting into an energized supply cable, the operating voltage shall be determined and appropriate precautions taken for handling conductors at that voltage.

c. When the insulating covering on energized wires or cables must be cut into, the employee shall use a tool designed for the purpose. While doing such work, suitable eye protection and insulating gloves with protectors shall be worn. Employees shall exercise extreme care to prevent short-circuiting conductors when cutting into the insulation.

5. Metal measuring tapes, and tapes or ropes containing metal threads or strands, shall not be used closer to exposed energized parts than the distance specified in Rule 441A. Care should be taken when extending metallic ropes or tapes parallel to and in the proximity of high-voltage lines because of the effect of induced voltages.

6. Equipment or material of a noninsulating substance that is not bonded to an effective ground and which extends into an energized area, and which could approach energized equipment closer than the distance specified in Rule 441A, shall be treated as though it is energized at the same voltage as the line or equipment to which it is exposed.

B. Requirement for assisting employee

In inclement weather or at night, no employee shall work alone outdoors on or dangerously in the vicinity of energized conductors or parts of more than 750 V between conductors.

EXCEPTION: This shall not preclude a qualified employee, working alone, from cutting trouble in the clear, switching, replacing fuses, or similar work if such work can be performed safely.

C. Opening and closing switches

Manual switches and disconnectors shall always be closed by a continuous motion. Care should be exercised in opening switches to avoid serious arcing.

D. Working position

Employees should avoid working on equipment or lines in any position from which a shock or slip will tend to bring the body toward exposed parts at a potential different than the employee's body. Work should, therefore, generally be done from below, rather than from above.

E. Protecting employees by switches and disconnectors

When equipment or lines are to be disconnected from any source of electric energy for the protection of employees, the switches, circuit breakers, or other devices designated and designed for operation under the load involved at sectionalizing points shall be opened or disconnected first. When re-energizing, the procedure shall be reversed.

F. Making connections

In connecting de-energized equipment or lines to an energized circuit by means of a conducting wire or device, employees should first attach the wire to the de-energized part. When disconnecting, the source end should be removed first. Loose conductors should be kept away from exposed energized parts.

G. Switchgear

Switchgear shall be de-energized and grounded per Rule 444D prior to performing work involving removal of protective barriers unless other suitable means are provided for employee protection. The personnel safety features in switchgear shall be replaced after work is completed.

H. Current transformer secondaries

The secondary of a current transformer shall not be opened while energized. If the entire circuit cannot be properly de-energized before working on an instrument, a relay, or other section of a current transformer secondary circuit, the employee shall bridge the circuit with jumpers so that the current transformer secondary will not be opened.

I. Capacitors

Before employees work on capacitors, the capacitors shall be disconnected from the energizing source, short-circuited, and grounded. Any line to which capacitors are connected shall be short-circuited and grounded before it is considered de-energized. Since capacitor units may be connected in series-parallel, each unit shall be shorted between all insulated terminals and the capacitor tank before handling. Where the tanks of capacitors are on ungrounded racks, the racks shall also be grounded. The internal resistor shall not be depended upon to discharge capacitors.

J. Gas-insulated equipment

Employees working on gas-insulated cable systems or circuit breakers shall be instructed concerning the special precautions required for possible presence of arcing by-products of sulfur-hexafluoride (SF_6).

NOTE: By-products resulting from arcing in sulfur-hexafluoride (SF_6) gas-insulated systems are generally toxic and irritant. Gaseous by-products can be removed for maintenance on the compartments by purging with air or dry nitrogen. The solid residue that must be removed is mostly metallic fluoride. This fine powder absorbs moisture and produces fluorides of sulfur and hydrofluoric acid, which are toxic and corrosive.

K. Attendant on surface

While electric supply personnel are in a manhole, an employee shall be available on the surface in the immediate vicinity to render assistance from the surface. This shall not preclude the employee on the surface from entering the manhole to provide short-term assistance.

EXCEPTION: This shall not preclude a qualified employee, working alone, from entering a manhole where energized cables or equipment are in service, for the purpose of inspection, housekeeping, taking readings, or similar work if such work can be performed safely.

L. Unintentional grounds on delta circuits

Unintentional grounds on delta circuits shall be removed as soon as practical.

444. De-energizing equipment or lines to protect employees

A. Application of rule

1. When employees must depend on others to operate switches or otherwise de-energize circuits on which they are to work, or must secure special authorization before they operate such switches themselves, the precautionary measures that follow shall be taken in the order given before work is begun.
2. If the employee under whose direction a section of a circuit is disconnected is in sole charge of the section and of the means of disconnection, those portions of the following measures that pertain to dealing with the designated person may be omitted.
3. Records shall be kept on all contractual utility interactive systems on any electric supply lines. When these lines are de-energized according to Rule 444C, the utility interactive system shall be visibly disconnected from the lines.

B. Employee's request

The employee in charge of the work shall apply to the designated person to have the particular section of equipment or lines de-energized, identifying it by position, letter, color, number, or other means.

C. Operating switches, disconnectors, open points, and tagging

1. The designated person shall direct the operation of all switches and disconnectors through which electric energy may be supplied to the particular section of equipment and lines to be de-energized, and shall direct that such switches and disconnectors be rendered inoperable and tagged. If switches that are controlled automatically or remotely or both can be rendered inoperable, they shall be tagged at the switch location. If it is impractical to render such switches and disconnectors inoperable, then these remotely controlled switches shall also be tagged at all points of control. A record shall be made when placing the tag, giving the time of disconnection, the name of the person making the disconnection, the name of the employee who requested the disconnection, and the name or title or both, of the designated person.
2. Air gaps created (e.g., cut or open jumpers) for de-energizing equipment or lines for the purpose of protecting employees shall be tagged and meet minimum clearances as specified in Table 444-1 or separated by a properly rated insulator.

D. Employee's protective grounds

When all designated switches and disconnectors have been operated, rendered inoperable where practical, and tagged in accordance with Rule 444C, and the employee has been given permission to work by the designated person, the employee in charge should immediately proceed to make the employee's own protective grounds or verify that adequate grounds have been applied (see Rule 445) on the disconnected lines or equipment. During the testing for potential and/or application of grounds, distances not less than those shown in Table 441-1, as applicable, shall be maintained.

Temporary protective grounds shall be placed at such locations and arranged in such a manner that affected employees are protected from hazardous differences in electrical potential.

NOTE: Hazardous touch and step potentials may exist around grounded equipment or between separately grounded systems. Additional measures for worker protection may include barriers, insulation, work practices, isolation or grounding mats.

The distance in Table 444-1, as applicable, shall be maintained from ungrounded conductors at the work location. Where the making of a ground is impractical, or the conditions resulting therefrom are more hazardous than working on the lines or equipment without grounding, the ground may be omitted by special permission of the designated person.

EXCEPTION: Alternative work methods such as isolation of equipment, lines, and conductors from all sources including induced voltages may be employed when the employer has assured worker protection from hazardous differences in electrical potential.

E. Proceeding with work

1. After the equipment or lines have been de-energized and grounded per Rule 444D, the employee in charge, and those under the direction of the employee in charge, may proceed with work on the de-energized parts.

   Equipment may be re-energized for testing purposes only under the supervision of the employee in charge and subject to authorization by the designated person.

2. Each additional employee in charge desiring the same equipment or lines to be de-energized and grounded per Rule 444D for the protection of that person, or the persons under direction, shall follow these procedures to secure similar protection.

F. Reporting clear—Transferring responsibility

1. The employee in charge, upon completion of the work and after ensuring that all persons assigned to this employee in charge are in the clear, shall remove protective grounds and shall report to the designated person that all tags protecting that person may be removed.

2. The employee in charge who received the permission to work may, if specifically permitted by the designated person, transfer the permission to work and the responsibility for persons by personally informing the affected persons of the transfer.

G. Removal of tags

1. The designated person shall then direct the removal of tags and the removal shall be reported back to the designated person by the persons removing them. Upon the removal of any tag, there shall be added to the record containing the name of the designated person or title or both, and the person who requested the tag, the name of the person requesting removal, the time of removal, and the name of the person removing the tag.

2. The name of the person requesting removal shall be the same as the name of the person requesting placement, unless responsibility has been transferred according to Rule 444F.

H. Sequence of re-energizing

Only after all protective grounds have been removed from the circuit or equipment and after protective tags have been removed in accordance with Rule 444G at a specific location, may the designated person direct the operation of switches and disconnectors at that location.

Table 444-1—Minimum clearances for open air gaps

Voltage in kilovolts phase-to-phase① ② ③	Electric supply stations		Overhead lines	
	(mm)	(in)	(mm)	(in)
1.0 to 8.3	178	7	127	5
8.4 to 15.5	305	12	178	7
15.6 to 27	381	15	229	9
27.1 to 38	458	18	305	12
38.1 to 48.2	534	21	534	21
48.3 to 72.5	788	31	788	31

① For single-phase lines off of three phase systems, use the phase-to-phase voltage of the system.
② For single-phase systems, use the highest voltage available.
③ Table values taken from IEEE Std C37.30.1™-2011 [B56].

445. Protective grounds

Extreme caution shall be exercised that the proper sequence of installing and removing protective grounds is followed.

A. Installing grounds

When installing protective grounds on a previously energized part, the following sequence and precautionary measures shall be observed.

EXCEPTION: In certain situations, such as when grounding conductors are supported on some high-voltage towers, it may be appropriate to perform the voltage test before bringing the grounding device into the work area.

1. Current-carrying capacity of grounds

   The grounding device shall be of such size as to carry the induced current and anticipated fault current that could flow at the point of grounding for the time necessary to clear the line.

   NOTE: Refer to ASTM F 855-04 [B22] for specifications for protective grounding equipment.

2. Initial connections

   Before grounding any previously energized part, the employee shall first securely connect one end of the grounding device to an effective ground. Grounding switches may be employed to connect the equipment or lines being grounded to the actual ground connections.

3. Test for voltage

   The previously energized parts that are to be grounded shall be tested for voltage except where previously installed grounds are clearly in evidence. The employee shall keep every part of the body at the required distance by using insulating handles of proper length or other suitable devices.

4. Completing grounds

   a. If the part shows no voltage, the grounding may be completed.

   b. If voltage is present, the source shall be determined to ensure that presence of this voltage does not prohibit completion of the grounding.

c. After the initial connections are made to ground, the grounding device shall next be brought into contact with the previously energized part using insulating handles or other suitable devices and securely clamped or otherwise secured thereto. Where bundled conductor lines are being grounded, grounding of each subconductor should be made. Only then may the employee come within the distances from the previously energized parts specified in Rule 441A or proceed to work upon the parts as upon a grounded part.

B. Removing grounds

1. The employee shall first remove the grounding devices from the de-energized parts using insulating tools or other suitable devices.

2. In the case of multiple ground cables connected to the same grounding point, all phase connections shall be removed before removing any of the ground connections.

   EXCEPTION: If the application of Rule 445B2 produces a hazard such as unintentional contact of the ground with ungrounded parts, then the grounds may be removed individually from each phase and ground connection.

3. The connection of the protective ground to the effective ground shall be removed last.

   NOTE 1: Hazards due to electric and magnetic field induction may exist when de-energized conductors, cables, and equipment are in proximity to other energized circuits.

   NOTE 2: IEEE Std 1048™-1990 [B47] and IEEE Std 1246™-2002 [B52] contain additional information for personal protective grounding.

446. Live work

All employees using live work practices shall observe the following rules in addition to applicable rules contained elsewhere in Sections 42 and 44.

The distances specified in Table 441-1 or Table 441-2 shall be maintained from all grounded objects and from other conductors, lines, and equipment having a potential different from that to which conductive equipment and devices are bonded in order to maintain the equipotentially energized work environment in an isolated state.

A. Training

Employees shall be trained in live work practices, which include rubber glove, hot stick, or barehand method, before being permitted to use these techniques on energized lines.

B. Equipment

1. Insulated aerial devices, ladders, and other support equipment used in live work shall be evaluated for performance at the voltages involved. Tests shall be conducted to ensure the equipment's integrity. Insulated aerial devices used in barehand work shall be tested before the work is started to ensure the integrity of the insulation. See applicable references in Section 3, specifically IEEE Std 516-2009 and ANSI/SIA A92.2-1992.

2. Insulated aerial devices and other equipment used in this work shall be maintained in a clean condition.

3. Tools and equipment shall not be used in a manner that will reduce the overall insulating strength of the insulated aerial device.

C. When working on insulators under live-line procedures, the clear insulation distance shall be not less than the distances required by Table 441-1 and Table 441-2.

D. Bonding and shielding for barehand method

1. A conductive bucket liner or other suitable conducting device shall be provided for bonding the insulated aerial device to the energized line or equipment.

2. The employee shall be bonded to the insulated aerial device by use of conducting shoes, leg clips, or other suitable means.

3. Adequate electrostatic shielding in the form of protective clothing that has been evaluated for electrical performance shall be provided and used where necessary.

   NOTE: Electrostatic shielding—Evaluation of protective clothing designed for this purpose is covered in IEEE Std 516-2009.

4. Before the employee contacts the energized part to be worked on, the aerial device shall be bonded to the energized conductor by means of a positive connection.

447. Protection against arcing and other damage while installing and maintaining insulators and conductors

In installing and maintaining insulators and conductors, precautions shall be taken to limit the opportunity for, as far as is practical, any damage that might render the conductors or insulators liable to fall. Precautions shall also be taken to prevent, as far as is practical, any arc from forming and to prevent any arc that might be formed from injuring or burning any parts of the supporting structures, insulators, or conductors.

Appendix A

(This Appendix is not part of Accredited Standards Committee C2, National Electrical Safety Code, 2017 Edition, and is included for information only.)

Uniform system of clearances adopted in the 1990 Edition

Reference: Rules 232, 233, and 234

Introduction

The uniform clearance system reflects the dimensions of expected activities in each area (reference component), as well as the relative potential problem caused by each type of facility (mechanical and electrical component).

Conductor clearances are stated in terms of the "closest approach," i.e., the clear distance that must be maintained under specified conditions.

— Vertical clearances are required during maximum sag conditions; they provide for expected activity beneath a line.

— Horizontal clearances are required when the conductor is at rest; they provide for expected activity alongside a line. In addition, displacement of conductors by wind is considered under certain conditions.

Under this system, users consider the actual characteristics of the materials and construction, rather than the reference characteristics built into the early Code requirements.

Three components are considered to determine the total clearance required:

— A *reference component* to cover activity in the area to be cleared by the overhead supply and/or communication lines. For example, truck height for over-the-road transport is limited to 4.3 m (14 ft) by state regulation. Thus the reference component for roads in Table 232-3 is 4.3 m (14 ft). Reference components included in the required clearances are shown in Table A-2.

— A *mechanical component* appropriate for the supply or communication line item. The mechanical component for neutral conductors meeting Rule 230E2 and open supply conductors is 610 mm (2 ft) (Table A-1).

— An *electrical component* appropriate for the voltage involved. The electrical component for open supply conductors, over 750 V to 22 kV, is 760 mm (2.5 ft) (Table A-1).

The required clearance is the sum of the three components: thus, 5.6 m (18.5 ft) is required for open supply conductors, over 750 V to 22 kV, over roads (Table 232-1). For purposes of illustration, the mechanical and electrical components are combined in Table A-1, and items with the same total mechanical and electrical components are grouped into similar clearance categories. Six groups are thus created.

Table A-1

Group	Category	R/NR (ft)	GI/O (ft)	M (ft)	E (ft)	M&E (ft)	M&E (mm/ m)
I	Support arms	1.0/—	0.0/—	1.0	0.0	1.0	305 mm
	Effectively grounded equipment cases	1.0/—	0.0/—	1.0	0.0		
II	Insulated communication conductors and cables	—/1.5	0.0/—	1.5	0.0	1.5	455 mm
	Messengers	—/1.5	0.0/—	1.5	0.0		
	Surge protection wires	—/1.5	0.0/—	1.5	0.0		
	Grounded guys	—/1.5	0.0/—	1.5	0.0		
	230E1	—/1.5	0.0/—	1.5	0.0		
	230C1	—/1.5	0.0/—	1.5	0.0		
III	URLP, 0 V to 750 V	1.0/—	—/0.5	1.5	0.5	2.0	610 mm
	Noninsulated communication conductors	—/1.5	—/0.5	2.0	0.0		
	230C2, 0 V to 750 V	—/1.5	0.0/—	1.5	0.5		
	230C3, 0 V to 750 V	—/1.5	0.0/—	1.5	0.5		
	Ungrounded cases of equipment at 0 to 750 V	1.0/—	—/0.5	1.5	0.5		
IV	230C2, greater than 750 V	—/1.5	0.0/—	1.5	1.0*	2.5	760 mm
	230C3, greater than 750 V	—/1.5	0.0/—	1.5	1.0*		
	Open supply conductors, 0 to 750 V ①	—/1.5	0.0/—	2.0	0.5*		
	230E2	—/1.5	0.0/—	2.0	0.5*		
V	URLP, greater than 750 V to 22 kV	1.0/—	—/0.5	1.5	2.5	4.0	1.2 m
	Ungrounded cases of equipment at greater than 750 V to 22 kV	1.0/—	—/0.5	1.5	2.5		
VI	Open supply conductors, greater than 750 V to 22 kV	—/1.5	—/0.5	2.0	2.5	4.5	1.37 m

NOTE 1: The portion(s) of guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not grounded have clearances based on the highest voltage to which they are exposed.
NOTE 2: An asterisk (*) beside a value indicates an exception to the legend.

①Does not include neutral conductors meeting Rule 230E1.

LEGEND

URLP — Unguarded rigid live parts
R — Rigid = 305 mm (1.0 ft)
NR — Nonrigid = 155 mm (1.5 ft)
GI — Grounded or insulated = 0.0 m (0.0 ft)
O — Bare, ungrounded, or open conductor or part = 152 mm (0.5 ft)
M — Mechanical component = R/NR plus GI/O
E — Electrical component
(a) Grounded and communication conductor = 0.0 m (0.0 ft)
(b) 0 V to 750 V = 152 mm (0.5 ft)
(c) Supply line greater than 750 V to 22 kV = 760 mm (2.5 ft)
M&E — Sum of M and E values

m

Table A-2a—Reference components of Rule 232

	Table 232-1		Table 232-2	
	Item	Ref (m)	Item	Ref (m)
	Where wires, conductors, or cables cross over or overhang		Where rigid parts overhang or along rights-of-way	
Track rails	1	6.7	—	—
Roads, streets, and other areas subject to truck traffic	2	4.3	1a	4.3
Driveways, parking lots, and alleys	3	4.3	1b	4.3
Other land traversed by vehicles	4	4.3	1c	4.3
Spaces and ways—pedestrians/restricted traffic	5	2.45/3.0	1d	2.45/3.0
Water areas—no sailboating	6	3.8	—	3.8
Water areas—sailboating	7		—	
(a) Less than 0.08 km^2		4.9		4.9
(b) Over 0.08 to 0.8 km^2		7.3		7.3
(c) Over 0.8 to 8 km^2		9.0		9.0
(d) Over 8 km^2		11.0		11.0
Areas posted for rigging or launching sailboats	8	See 7	—	
Where wires, conductors, or cables run along and within the limits of highways or other road rights-of-way, but do not overhang the roadway				
Roads, streets, or alleys	9	4.3	2a	4.3
Areas where vehicles unlikely	10	3.65	2b	3.65

NOTE 1: Under Table 232-1 reference, the 2.45 m reference height is used with Group II category of Table A-1 and the 3.0 m reference height is used with Groups IV and VI category.

NOTE 2: Under Table 232-2 reference, the 2.45 m reference height is used with Group I category of Table A-1 and the 3.0 m reference height is used with Groups III and V category.

ft

Table A-2a—Reference components of Rule 232

	Table 232-1		Table 232-2	
	Item	Ref (ft)	Item	Ref (ft)
	Where wires, conductors, or cables cross over or overhang		Where rigid parts overhang or along rights-of-way	
Track rails	1	22.0	—	—
Roads, streets, and other areas subject to truck traffic	2	14.0	1a	14.0
Driveways, parking lots, and alleys	3	14.0	1b	14.0
Other land traversed by vehicles	4	14.0	1c	14.0
Spaces and ways—pedestrians/restricted traffic	5	8.0/10.0	1d	8.0/10.0
Water areas—no sailboating	6	12.5	—	12.5
Water areas—sailboating	7		—	
(a) Less than 20 acres		16.0		16.0
(b) Over 20 to 200 acres		24.0		24.0
(c) Over 200 to 2000 acres		30.0		30.0
(d) Over 2000 acres		36.0		36.0
Areas posted for rigging or launching sailboats	8	See 7	—	
Where wires, conductors, or cables run along and within the limits of highways or other road rights-of-way, but do not overhang the roadway				
Roads, streets, or alleys	9	14.0	2a	14.0
Areas where vehicles unlikely	10	12.0	2b	12.0

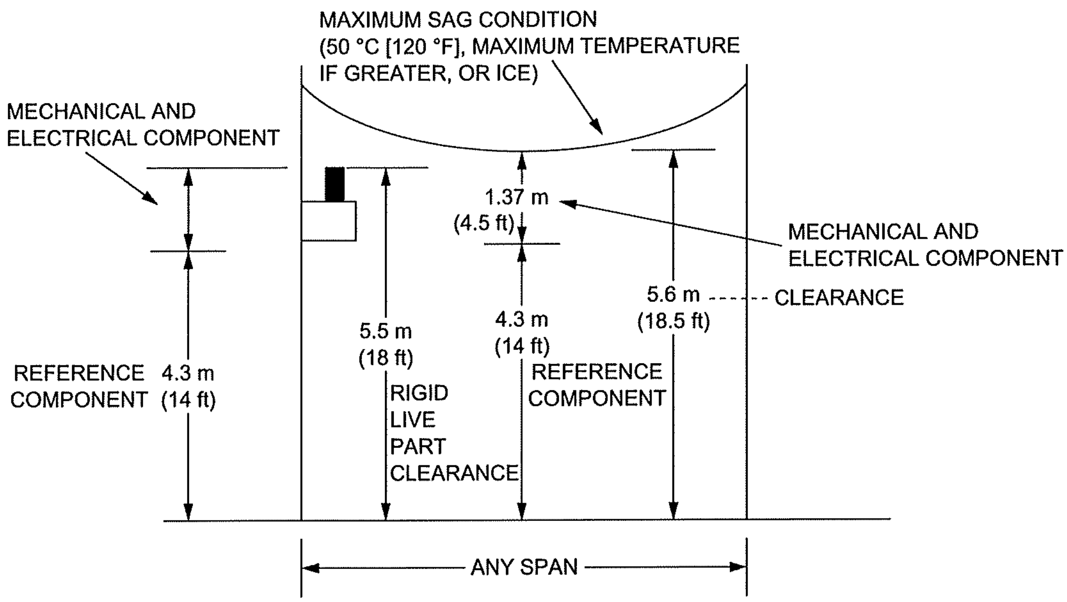
NOTE 1: Under Table 232-1 reference, the 8.0 ft reference height is used with Group II category of Table A-1 and the 10.0 ft reference height is used with Groups IV and VI category.

NOTE 2: Under Table 232-2 reference, the 8.0 ft reference height is used with Group I category of Table A-1 and the 10.0 ft reference height is used with Groups III and V category.

Table A-2b—Reference components of Rule 234

Reference table	Item	Ref (mm/m)	Ref (ft)
Table 234-1	1. Buildings		
	a. Horizontal		
	(1) Walls, projections, and guarded windows	915 mm	3.0
	(2) Unguarded windows	915 mm	3.0
	(3) Balconies and areas accessible to pedestrians	915 mm	3.0
	b. Vertical		
	(1) Roofs/projections not accessible to pedestrians	2.44 m	8.0
	(2) Balconies and roofs accessible to pedestrians	2.74 m	9.0
	(3) Roofs—vehicles not over 2.4 m (8 ft)	2.74 m	9.0
	(4) Roofs—vehicles over 2.4 m (8 ft)	4.3 m	14.0
	2. Signs, chimneys, billboards, antennas, tanks, etc.		
	a. Horizontal	915 mm	3.0
	b. Vertical over or under: not accessible to pedestrians	1.07 m	3.5
	c. Vertical over or under: accessible to pedestrians	2.74 m	9.0
Table 234-2	1. Over bridges		
	a. Attached	305 mm	1.0
	b. Not attached	2.44 m	8.0
	2. Beside, under, or within bridge structure		
	a. Accessible		
	(1) Attached	305 mm	1.0
	(2) Not attached	915 mm	3.0
	b. Inaccessible		
	(1) Attached	305 mm	1.0
	(2) Not attached	610 mm	2.0
Table 234-3	1. From water level, edge of pool, etc.	6.25 m	20.5
	2. From diving platform or tower	3.8 m	12.5

Vertical clearances now apply at the maximum conductor sag condition, such as outlined in Rule 232A, rather than at a 15 °C (60 °F) conductor temperature condition as used in the 1987 Edition. This is illustrated in Figure A-1: 5.6 m (18.5 ft) is required for open supply conductors, over 750 V to 22 kV, over roads, for any sag condition or span length.



CONDITION–CLEARANCE OF OPEN SUPPLY CONDUCTORS, 750 V–22 kV, ABOVE ROADS
CLEARANCE (5.6 m [18.5 ft]) = REFERENCE COMPONENT (4.3 m [14 ft])
+ MECHANICAL AND ELECTRICAL COMPONENT (1.37 m [4.5 ft])

Figure A-1—Clearance at maximum sag

Horizontal clearances to buildings and other installations now apply with the conductor at rest (no wind displacement) as outlined in Rule 234A.

Wind displacement need be considered only for energized open supply conductors and 230C2–230C3 cables energized at more than 750 V; see Rule 234C1.

Because application rules were revised in 1990, *it must be understood that clearance values cannot be directly compared between the 1987 and later editions.*

The following changes were also made to consolidate requirements and simplify application:

- Voltages in the tables are limited to 0 V to 750 V and over 750 V to 22 kV, normal secondary and primary distribution ranges respectively. Voltages in the 22 kV to 50 kV range are covered by a 10 mm per kV (0.4 in per kV) adder; see Rules 232C1a, 232C2a, and 234G1. Exceptions at 22 kV to 50 kV are noted where they apply.
- Rules for voltages above 22 kV and the alternate clearances for voltages above 98 kV are consolidated.
- Clearances for equipment cases are relocated from Rules 286E and 286F to Rules 232B3 and 234J.

Appendix B

(This Appendix is not part of Accredited Standards Committee C2, National Electrical Safety Code, 2017 Edition, and is included for information only.)

Uniform clearance calculations for conductors under ice and wind conditions adopted in the 2007 Edition

Rules 230, 232A, 233A1a(3), 234A1, 235C2b(1)(c), Definitions

Considerable activity over a period of several years took place preparing Change Proposals for the 2007 Code Edition. These proposals reflect subcommittee response to proposed changes in strength and loading rules, and are in preparation for further potential changes.

A major issue addressed was that of the greater conductor sag that will result from the increased radial ice thickness shown on the new ice map (Figure 250-3) in Section 25. These increases have made it necessary to reevaluate the impact such sags would have by effectively reducing overhead clearances. Furthermore it appears that the revised map(s) may become the only source of icing information in the future and may be updated periodically. Ice and wind maps as published by the American Society of Civil Engineers are important sources of meteorological information especially prepared for structural design.

A study using a spread of commonly used power cables revealed that in many areas very significant sag increases would result from increased ice, as compared to those values shown in Table 250-1. To respond to this challenge a working group comprised of members from Subcommittees 4 and 5 was formed to devise viable solutions. Few constraints were placed on their work except that the *level of safety currently in effect must not be compromised.*

Working Group activities

Several approaches were suggested as possible mitigating solutions. Each had merit and essentially achieved a reduction in sag by rationalizing a lesser thickness than was called for in the revised ice map. One such method lowered the storm return period from the established base line of 50 years (2% probability in a given year) to 12 or 15 years (8-1/3% to 6-2/3% probability in a given year). The method had merit, was carefully evaluated, but had some apparent disadvantages.

A more simple and direct approach which received universal Working Group acceptance, recognized that the new ice map is used exclusively for *calculating ice and wind loads as related to strength and loading.* Alternatively, when calculating sag for *clearance purposes,* a separate and different ice/wind map appearing in *Section 23* would be employed, which is equivalent to the present Figure 250-1.

The loading district terminology heavy, medium, and light has been replaced by clearance zones 1, 2, and 3, respectively. This eliminates the potential for confusion between the ice/wind requirements to be applied in both Sections 23 and 25, if Section 25 changes in the future. Section 23 will contain all clearance rules, as is appropriate, and will apply sags that are *derived* from radial ice thickness requirements in the *2002 Edition.* The credibility of these clearances was established many years ago since they are based upon a safety record of some 70 years of success.

Calculating clearance 2007 Edition

The following is a brief description of the methodology for calculating clearance related sags:

— Rule 230B1. Clearance zones have replaced "loading districts" for classifying areas where combined ice and wind effects on conductors are essentially equivalent. Clearance zones 1, and 2, and 3 are equivalent to heavy-, medium-, and light-loading districts in the 2002 Edition. These zones are shown in new Figure 230-1. The boundaries for this map are unchanged from previous editions of Rule 250.

— Table 230-1 and Table 230-2. These tables show in tabular form the radial ice thickness, wind pressure, temperatures, and additive constants used to calculate clearance sags. Long term creep determination requires additional information that is not provided in the code and may or may not be a factor in a given design. The specified radial ice, wind pressures, temperatures, and additive constants in the three zones are the same as those in Rule 250 of the 2002 Edition.

— Sag definitions. These have been slightly modified for reasons discussed under *conductor creep* in this Appendix.

— Rules 232A3, 233A1a(3), 234A1, and 235C2b(1)(c). Appropriate additions of, and deletions to, these rules were necessary in order to account for the move of clearance related calculations from Section 25 to Section 23 in the 2007 Edition.

— Rule 230B3. This rule is the equivalent of Rule 251A of the 2007 Edition.

— Rule 230B4. This rule is the equivalent of Rule 251B of the 2002 Edition.

Conductor creep

Creep is a complex physical property of most structural metals and relates to strain hardening and boundary movement at the molecular level. It is important in the design of many transmission lines, as well as in some distribution designs. It is mentioned in the 2002 and previous editions. Unfortunately, it is not always well understood, especially the difference between *initial stretch* and *creep,* the latter being a function of both temperature and time. Both, however, are forms of *inelastic deformation,* but occur over very different time periods.

All conductors and support messengers experience initial stretch immediately upon loading. Upon removal of the load, the conductor will return to an unloaded position that is displaced from the initial position. Repeated loading to higher magnitudes progressively shifts the elastic line, and the linear relationship between load and strain thereafter acts along this line.

Creep however, varies as a function of time, but not linearly. Some conductors are provided with creep curves covering different periods of time at specified temperatures. Many engineers consider 10 years as the practical limit for creep to increase, after which time it remains fairly static.

Experience has also shown that steel is much less prone to creep as compared to aluminum or copper, and is commonly ignored for steel wires and messengers. Aluminum conductors on the other hand are highly susceptible to creep, particularly at elevated temperatures, and usually require attention during the design stage.

The unique characteristics of creep and its occasional confusion with initial stretch led the working group to strike parenthetical creep from the definitions of sag. Creep remains a factor engineers must consider in their work with the Code because it is a form of inelastic deformation. The action also removed the apparent (and probably unintentional) emphasis placed on creep, when in fact for smaller conductors it generally has less impact on clearance than does initial stretch.

Summary

The Code safety principles, and design practices, have for over seventy years successfully protected both the public and utility workers from injury and death. The *same* standards have been carefully applied while developing these revisions. Changes in the 2007 Edition with respect to clearance calculations may be characterized as follows:

— All requirements for overhead line clearances are now incorporated in Section 23.

— Calculations to meet electrical and mechanical clearance requirements remain essentially unchanged.

— Responsible subcommittees exercise complete control in their area. This will allow for potentially different treatment of conductor tension and conductor sags when applied to structural loading and to clearances in the future.

— Persons not familiar with strength concerns are not encumbered with unrelated design issues, and vice versa.

— Subcommittees 4 and 5 will be better postured to work with other standards producing organizations.

— Improved and updated weather maps and similar aids can be more readily implemented.

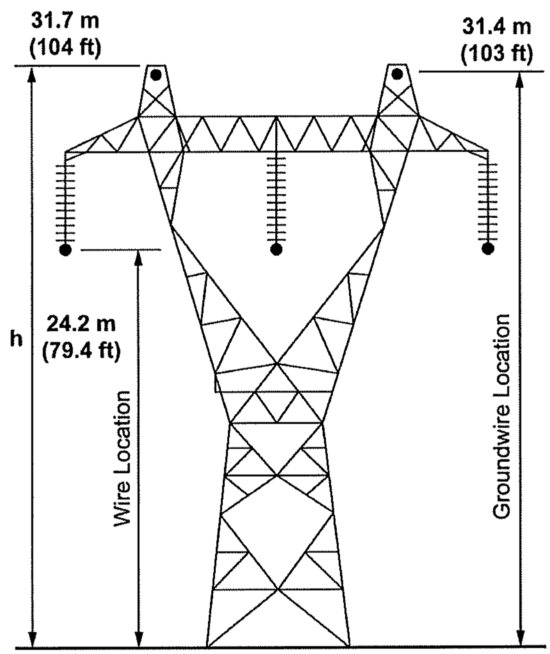
Appendix C

(This Appendix is not part of Accredited Standards Committee C2, National Electrical Safety Code, 2017 Edition, and is included for information only.)

Example applications for Rule 250C Table 250-2 and Table 250-3

The following examples demonstrate the use of Table 250-2 and Table 250-3. The method of selecting the design parameters should not be considered the recommended method for the structures presented in these examples. The method used for determining the design values should be based on engineering judgment.

Example 1 illustrates the basic application for determining the tower and wire wind loads. The tower wind load is uniformly distributed over the tower height (h). The structure is a lattice tower with flat-surfaced members.



Example 1

Step 1: Determine the wind pressure for the phase conductors

Using Table 250-2, select a wire k_z value, velocity pressure exposure coefficient:

The k_z for the wire is based on the height, h, of the wire at the structure (Rule 250C1), h = 24.2 m (79.4 ft); therefore from Table 250-2, $\mathbf{k_z} = \mathbf{1.20}$. The table k_z values represent, approximately, the upper limit for the range of heights, h. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$k_z = 2.01 \cdot (24.2 \text{ m}/275 \text{ m})^{(2/9.5)} = \mathbf{1.205}$
$k_z = 2.01 \cdot (79.4 \text{ ft}/900 \text{ ft})^{(2/9.5)} = \mathbf{1.205}$

Using Table 250-3, select a wire G_{RF} value, gust response factor:

The wire gust response factor, G_{RF}, is determined using the height of the wire at the structure, h = 24.2 m (79.4 ft), and the design wind span, L. The design span for this example is assumed to be 400 m (1310 ft). Using Table 250-3, the Wire $\mathbf{G_{RF}}$ equals **0.69**. The table values represent, approximately, the upper limit of the G_{RF} value based on the upper limit for the range of heights, h, and lower limit for the range of span lengths, L. The equations of Table 250-3 can be used to determine the exact value of $\mathbf{G_{RF}}$.

$B_w = 1/(1 + 0.8 \cdot 400\ m/67) = 0.173$ $E_w = 0.346 \cdot (10/24.2\ m)^{1/7} = 0.305$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.305 \cdot (0.173)^{0.5})]/ (1.43)^2 = \mathbf{0.657}$
$B_w = 1/(1 + 0.8 \cdot 1310\ ft/220) = 0.173$ $E_w = 0.346 \cdot (33/79.4\ ft)^{1/7} = 0.305$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.305 \cdot (0.173)^{0.5})]/ (1.43)^2 = \mathbf{0.657}$

The wire wind pressure, assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure = $0.613 \cdot (40\ m/s)^2 \cdot 1.2 \cdot 0.69 \cdot 1.0 \cdot 1.0 =$ **812 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ mph)^2 \cdot 1.2 \cdot 0.69 \cdot 1.0 \cdot 1.0 =$ **17.17 psf**

Step 2: Determine the wind pressure for the overhead groundwire

Using Table 250-2, select a wire k_z value, velocity pressure exposure coefficient:

The k_z for the wire is based on the height, h, of the wire at the structure (Rule 250C1), h = 31.4 m (103 ft); therefore from Table 250-2, $\mathbf{k_z}$ = **1.30**. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$\mathbf{k_z} = 2.01 \cdot (31.4\ m/275\ m)^{(2/9.5)} = \mathbf{1.273}$
$\mathbf{k_z} = 2.01 \cdot (103\ ft/900\ ft)^{(2/9.5)} = \mathbf{1.273}$

Using Table 250-3, select a wire G_{RF} value, gust response factor:

The wire gust response factor, G_{RF}, is determined using the height of the wire at the structure, h = 31.4 m (103 ft), and the design wind span, L = 400 m (1310 ft). Using Table 250-3, the overhead groundwire $\mathbf{G_{RF}}$ equals **0.68**. The equations of Table 250-3 can be used to determine the exact value of $\mathbf{G_{RF}}$.

$B_w = 1/(1 + 0.8 \cdot 400\ m/67) = 0.173$ $E_w = 0.346 \cdot (10/31.4\ m)^{1/7} = 0.294$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.294 \cdot (0.173)^{0.5})] / (1.43)^2 = \mathbf{0.650}$

$B_w = 1/(1 + 0.8 \cdot 1310\ ft/220) = 0.173$ $E_w = 0.346 \cdot (33/103\ ft)^{1/7} = 0.294$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.294 \cdot (0.173)^{0.5})]/ (1.43)^2 = \mathbf{0.650}$

The overhead groundwire wind pressure, assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure = $0.613 \cdot (40\ m/s)^2 \cdot 1.3 \cdot 0.68 \cdot 1.0 \cdot 1.0 =$ **867 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ mph)^2 \cdot 1.3 \cdot 0.68 \cdot 1.0 \cdot 1.0 =$ **18.33 psf**

Step 3: Determine the wind pressure for the structure

Using Table 250-2, select the structure k_z value, velocity pressure exposure coefficient:

The k_z for the structure is based on the total structure height, h, above the ground line (Rule 250C1), h = 31.7 m (104 ft); therefore from Table 250-2, $\mathbf{k_z} = \mathbf{1.20}$. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$\mathbf{k_z} = 2.01 \cdot (0.67 \cdot 31.7\ m/275\ m)^{(2/9.5)} = \mathbf{1.172}$
$\mathbf{k_z} = 2.01 \cdot (0.67 \cdot 104\ ft/900\ ft)^{(2/9.5)} = \mathbf{1.172}$

It should be noted that the structure center of wind pressure is assumed at 2/3 the structure height for the values obtained from Table 250-2. This assumption is included in the table values and the table equation E_s with the adjustment factor 0.67. This assumption is appropriate when the wind speed is assumed uniformly distributed over the structure height and the structure height is equal to or less than 75 m. Example 3 will demonstrate when the 2/3 assumption should not be used.

Using Table 250-3, select a structure G_{RF} value, gust response factor:

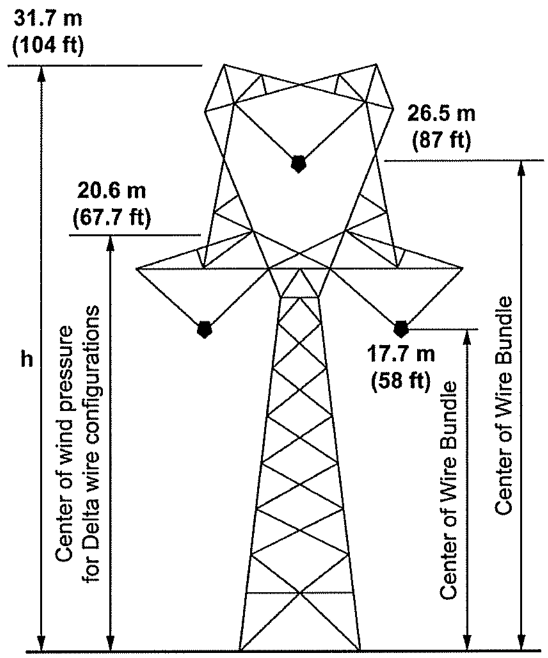
The structure gust response factor, G_{RF}, is determined using the total structure height, h = 31.7 m (104 ft). Using Table 250-3, the structure $\mathbf{G_{RF}}$ equals **0.89**. The equations of Table 250-3 can be used to determine the exact value of $\mathbf{G_{RF}}$.

$B_s = 1/(1 + 0.375 \cdot 31.7\ m/67) = 0.849$ $E_s = 0.346 \cdot (10/[0.67 \cdot 31.7\ m])^{1/7} = 0.311$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.311 \cdot (0.849)^{0.5})] / (1.43)^2 = \mathbf{0.867}$
$B_s = 1/(1 + 0.375 \cdot 104\ ft/220) = 0.849$ $E_s = 0.346 \cdot (33/[0.67 \cdot 104\ ft])^{1/7} = 0.311$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.311 \cdot (0.849)^{0.5})]/ (1.43)^2 = \mathbf{0.867}$

The structure wind pressure (uniformly distributed), assuming 40 m/s (90 mph), I equals 1.0, C_f equals 3.2, and the table values for k_z and G_{RF}, is:

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 1.20 \cdot 0.89 \cdot 1.0 \cdot 3.2 = \mathbf{3352\ newtons/m^2}$
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 1.2 \cdot 0.89 \cdot 1.0 \cdot 3.2 = \mathbf{70.87\ psf}$

Example 2 illustrates the calculation of the wind load at the assumed geometric center (centroid) of a Delta wire configuration.



Example 2

Determine the wind pressure for the phase conductors.

Using Table 250-2, select a wire k_z value, velocity pressure exposure coefficient:

The k_z for the wire is based on the height, h, of the center of wind pressure for the Delta wire configuration, h = 20.6 m (67.7 ft); therefore from Table 250-2, $\mathbf{k_z = 1.20}$. The equations of Table 250-2 can be used to determine the exact value $\mathbf{k_z}$.

$k_z = 2.01 \cdot (20.6\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.165}$
$k_z = 2.01 \cdot (67.7\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.165}$

Using Table 250-3, select a wire G_{RF} value, gust response factor:

The wire gust response factor, G_{RF}, is determined using the height of the wire at the center of the Delta wire configuration, h = 20.6 m (67.7 ft), and the design wind span, L. The design wind span for this example is assumed to be 275 m (900 ft). Using the table, the wire $\mathbf{G_{RF}}$ equals **0.71**. The equations of Table 250-3 can be used to determine the exact value of $\mathbf{G_{RF}}$.

$B_w = 1/(1 + 0.8 \cdot 275\ \text{m}/67) = 0.233$ $E_w = 0.346 \cdot (10/20.6\ \text{m})^{1/7} = 0.312$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.312 \cdot (0.233)^{0.5})] / (1.43)^2 = \mathbf{0.688}$
$B_w = 1/(1 + 0.8 \cdot 900\ \text{ft}/220) = 0.233$ $E_w = 0.346 \cdot (33/67.7\ \text{ft})^{1/7} = 0.312$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.312 \cdot (0.233)^{0.5})] / (1.43)^2 = \mathbf{0.688}$

The wire wind pressure, assuming 38 m/s (85 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure $= 0.613 \cdot (38\ \text{m/s})^2 \cdot 1.2 \cdot 0.71 \cdot 1.0 \cdot 1.0 =$ **754 newtons/m²**
Wind pressure $= 0.00256 \cdot (85\ \text{mph})^2 \cdot 1.2 \cdot 0.71 \cdot 1.0 \cdot 1.0 =$ **15.76 psf**

Example 3 illustrates the application of a non-uniform wind load distribution for structures taller than 250 ft. This procedure may also be used on structures less than 250 ft when in the engineer's judgment a detailed wind load distribution is desired. The example structure is a lattice tower with flat-surfaced members.

Step 1: Determine assumed wind load distribution

This structure is assumed to have 4 different wind sections (WS) each with its specific uniform wind load. Wind Section #1 (WS#1) was determined by engineering judgment to be the height, h, from the ground line to the top of the tapered leg, h = 69.5 m (228 ft). The center of wind pressure for WS#1 is assumed to be 2/3 the height of 69.5 m (228 ft). WS#2 is assumed to be the distance between the top of the tapered leg to the bottom of the middle crossarm. The center of wind pressure for WS#2 is assumed to be at the mid-height of this wind section, h = 75.8 m (248 ft). Similar assumptions are made for WS#3, h = 88.3 m (290 ft), and WS#4, h = 100.3 m (329 ft).

Step 2: Determine the wind load for each structure wind section

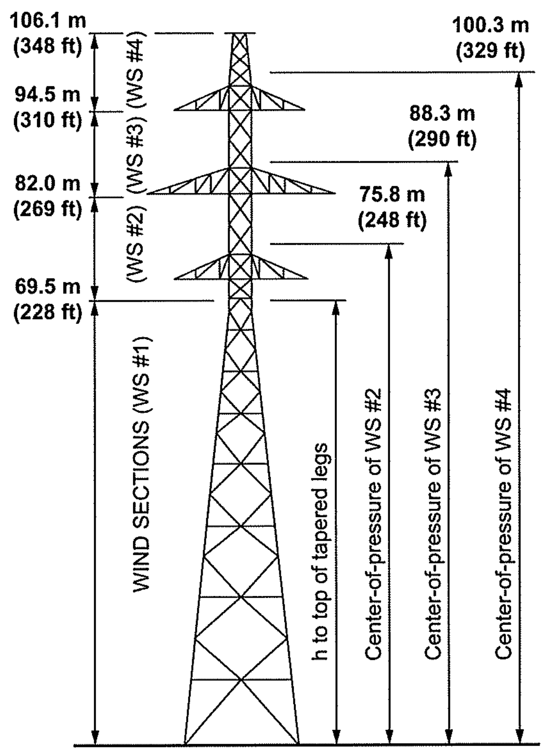
For WS#1, determine the uniformly distributed wind load.

Determine k_z, h = 69.5 m (228 ft), using Table 250-2, $\mathbf{k_z} = \mathbf{1.40}$, using the equations:

$\mathbf{k_z} = 2.01 \cdot (0.67 \cdot 69.5\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.383}$
$\mathbf{k_z} = 2.01 \cdot (0.67 \cdot 228\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.383}$

Determine G_{RF}. The structure gust response factor is a function of the structures dynamic response. Therefore a single value of G_{RF} using the total structure height should be used on all structure wind sections. Given h = 106.1 m (348 ft), using the equations:

$B_s = 1/(1 + 0.375 \cdot 106.1\ \text{m}/67) = 0.627$ $E_s = 0.346 \cdot (10/[0.67 \cdot 106.1\ \text{m}])^{1/7} = 0.261$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.261 \cdot (0.627)^{0.5})] / (1.43)^2 = \mathbf{0.762}$
$B_s = 1/(1 + 0.375 \cdot 348\ \text{ft}/220) = 0.627$ $E_s = 0.346 \cdot (33/[0.67 \cdot 348\ \text{ft}])^{1/7} = 0.261$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.261 \cdot (0.627)^{0.5})] / (1.43)^2 = \mathbf{0.762}$



Example 3

The structure wind pressure (uniformly distributed over WS#1) assuming 40 m/s (90 mph), I equals 1.0, C_f equals 3.2:

Wind pressure $= 0.613 \cdot (40\ \text{m/s})^2 \cdot 1.40 \cdot 0.762 \cdot 1.0 \cdot 3.2 = \mathbf{3348\ newtons/m^2}$
Wind pressure $= 0.00256 \cdot (90\ \text{mph})^2 \cdot 1.40 \cdot 0.762 \cdot 1.0 \cdot 3.2 = \mathbf{70.79\ psf}$

For WS#2, determine the uniformly distributed wind load.

Determine k_z, h = 75.8 m (248 ft), using the equations:

$k_z = 2.01 \cdot (75.8\ m/275\ m)^{(2/9.5)} = \mathbf{1.53}$
$k_z = 2.01 \cdot (248\ ft/900\ ft)^{(2/9.5)} = \mathbf{1.53}$

G_{RF} = 0.762 for the overall structure, thus the structure wind pressure (uniformly distributed over WS#2) assuming 40 m/s (90 mph), I equals 1.0, C_f equals 3.2:

Wind pressure = $0.613 \cdot (40\ m/s)^2 \cdot 1.53 \cdot 0.762 \cdot 1.0 \cdot 3.2$ = **3659 newtons/m^2**
Wind pressure = $0.00256 \cdot (90\ mph)^2 \cdot 1.53 \cdot 0.762 \cdot 1.0 \cdot 3.2$ = **77.36 psf**

For WS#3, determine the uniformly distributed wind load.

Determine k_z, h = 88.3 m (290 ft), using the equations:

$k_z = 2.01 \cdot (88.3\ m/275\ m)^{(2/9.5)} = \mathbf{1.58}$
$k_z = 2.01 \cdot (290\ ft/900\ m)^{(2/9.5)} = \mathbf{1.58}$

G_{RF} = 0.762. The structure wind pressure (uniformly distributed over WS#3) assuming 40 m/s (90 mph), I equals 1.0, C_f equals 3.2:

Wind pressure = $0.613 \cdot (40\ m/s)^2 \cdot 1.58 \cdot 0.762 \cdot 1.0 \cdot 3.2$ = **3779 newtons/m^2**
Wind pressure = $0.00256 \cdot (90\ mph)^2 \cdot 1.58 \cdot 0.762 \cdot 1.0 \cdot 3.2$ = **79.89 psf**

For WS#4, determine the uniformly distributed wind load. Determine k_z, h = 100.3 m (329 ft), using the equations:

$k_z = 2.01 \cdot (100.3\ m/275\ m)^{(2/9.5)} = \mathbf{1.63}$
$k_z = 2.01 \cdot (329\ ft/900\ ft)^{(2/9.5)} = \mathbf{1.63}$

G_{RF} = 0762. The structure wind pressure (uniformly distributed over WS#4) assuming 40 m/s (90 mph), I equals 1.0, C_f equals 3.2:

Wind pressure = $0.613 \cdot (40\ m/s)^2 \cdot 1.63 \cdot 0.762 \cdot 1.0 \cdot 3.2$ = **3898 newtons/m^2**
Wind pressure = $0.00256 \cdot (90\ mph)^2 \cdot 1.63 \cdot 0.762 \cdot 1.0 \cdot 3.2$ = **82.42 psf**

Example 4 illustrates the application of the wind load on a distribution wood structure. The purpose of this example is to demonstrate the concept provided in Rule 250C. Engineering judgment should be used when selecting the wind parameters to use with Table 250-2 and Table 250-3.

Step 1: Determine the wind pressure for the phase conductors

Using Table 250-2, select a wire k_z value, velocity pressure exposure coefficient:

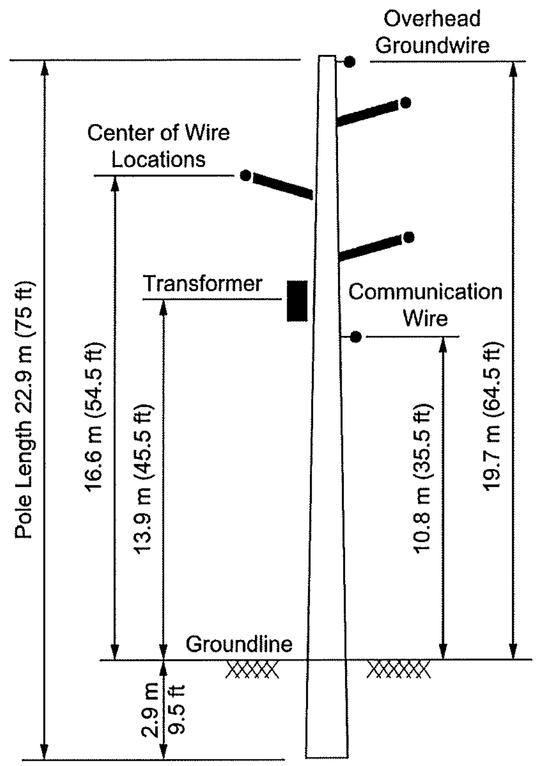
The k_z for the wire is based on the height, h, of the center wire at the structure (Rule 250C1), h = 16.6 m (54.5 ft); therefore from Table 250-2, $\mathbf{k_z}$ = **1.20**. The table k_z values represent, approximately, the upper limit of the range of height, h. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$\mathbf{k_z} = 2.01 \cdot (16.6\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.113}$
$\mathbf{k_z} = 2.01 \cdot (54.5\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.113}$

Using Table 250-3, select a wire G_{RF} value, gust response factor:

The wire gust response factor, G_{RF}, is determined using the height of the wire at the structure, h = 16.6 m (54.5 ft), and the design wind span, L. The design span for this example is assumed to be 152 m (500 ft). Using Table 250-3, the wire $\mathbf{G_{RF}}$ equals **0.75**. The table wire G_{RF} values represent, approximately, the upper limit of the G_{RF} value based on the upper limit of height, h, and lower limit of span length, L. The equations of Table 250-3 can be used to determine the exact values of $\mathbf{G_{RF}}$.

$B_w = 1/(1 + 0.8 \cdot 152\ \text{m}/67) = 0.355$ $E_w = 0.346 \cdot (10/16.6\ \text{m})^{1/7} = 0.322$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.322 \cdot (0.355)^{0.5})]/(1.43)^2 = \mathbf{0.742}$
$B_w = 1/(1 + 0.8 \cdot 500\ \text{ft}/220) = 0.355$ $E_w = 0.346 \cdot (33/54.5\ \text{ft})^{1/7} = 0.322$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.322 \cdot (0.355)^{0.5})]/(1.43)^2 = \mathbf{0.742}$



Example 4

The wire wind pressure, assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 1.2 \cdot 0.75 \cdot 1.0 \cdot 1.0 =$ **883 newtons/m²**	
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 1.2 \cdot 0.75 \cdot 1.0 \cdot 1.0 =$ **18.66 psf**	

Step 2: Determine the wind pressure for the overhead groundwire

Using Table 250-2, select a wire k_z value, velocity pressure exposure coefficient:

The k_z for the wire is based on the height, h, of the wire at the structure (Rule 250C1), h = 19.7 m (64.5 ft); therefore from Table 250-2, $\mathbf{k_z} = \mathbf{1.20}$. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$k_z = 2.01 \cdot (19.7\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.154}$
$k_z = 2.01 \cdot (64.5\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.154}$

Using Table 250-3, select a wire G_{RF} value, gust response factor:

The wire gust response factor, G_{RF}, is determined using the height of the wire at the structure, h = 19.7 m (64.5 ft), and the design wind span, L = 152 m (500 ft). Using Table 250-3, the overhead groundwire $\mathbf{G_{RF}}$ equals **0.75**. The equations of Table 250-3 can be used to determine the exact value of $\mathbf{G_{RF}}$.

$B_w = 1/(1 + 0.8 \cdot 152\ \text{m}/67) = 0.355$ $E_w = 0.346 \cdot (10/19.7\ \text{m})^{1/7} = 0.314$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.314 \cdot (0.355)^{0.5})] / (1.43)^2 = \mathbf{0.736}$
$B_w = 1/(1 + 0.8 \cdot 500\ \text{ft}/220) = 0.355$ $E_w = 0.346 \cdot (33/64.5\text{ft})^{1/7} = 0.314$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.314 \cdot (0.355)^{0.5})]/ (1.43)^2 = \mathbf{0.736}$

The overhead groundwire wind pressure, assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure $= 0.613 \cdot (40\ \text{m/s})^2 \cdot 1.2 \cdot 0.75 \cdot 1.0 \cdot 1.0 =$ **883 newtons/m²**
Wind pressure $= 0.00256 \cdot (90\ \text{mph})^2 \cdot 1.2 \cdot 0.75 \cdot 1.0 \cdot 1.0 =$ **18.66 psf**

Step 3: Determine the wind pressure for the structure

Using Table 250-2, select the structure k_z value, velocity pressure exposure coefficient:

The k_z for the structure is based on the total structure height, h, above the ground line (Rule 250C1), h = 22.9 m – 2.9 m = 20.0 m (75 ft – 9.5 ft = 65.5 ft); therefore from Table 250-2, $\mathbf{k_z = 1.10}$. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$k_z = 2.01 \cdot (0.67 \cdot 20.0\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.064}$
$k_z = 2.01 \cdot (0.67 \cdot 65.5\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.064}$

It should be noted that the structure center of wind pressure is assumed at 2/3 the structure height for the values obtained from Table 250-2. This assumption is included in the table values and the table equation E_s with the adjustment factor 0.67. This assumption is appropriate when the wind speed is assumed uniformly distributed over the structure height and the structure height is equal to or less than 75 m. Example 3 demonstrates when the 2/3 assumption should not be used.

Using Table 250-3, select a structure G_{RF} value, gust response factor:

The structure gust response factor, GRF, is determined using the total structure height, h = 31.7 m. Gust response factor, G_{RF}, is determined using the height of the wire at the structure, h = 20.0 m (65.5 ft). Using Table 250-3, the structure $\mathbf{G_{RF}}$ equals **0.93**. The equations of Table 250-3 can be used to determine the exact values of $\mathbf{G_{RF}}$.

$B_s = 1/(1 + 0.375 \cdot 20\ \text{m}/67) = 0.899$ $E_s = 0.346 \cdot (10/[0.67 \cdot 20\ \text{m}])^{1/7} = 0.332$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.332 \cdot (0.899)^{0.5})] / (1.43)^2 = \mathbf{0.905}$
$B_s = 1/(1 + 0.375 \cdot 65.5\ \text{ft}/220) = 0.899$ $E_s = 0.346 \cdot (33/[0.67 \cdot 65.5\ \text{ft}])^{1/7} = 0.332$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.332 \cdot (0.899)^{0.5})]/ (1.43)^2 = \mathbf{0.905}$

The structure wind pressure (uniformly distributed), assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 1.10 \cdot 0.93 \cdot 1.0 \cdot 1.0 =$ **1003 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 1.10 \cdot 0.93 \cdot 1.0 \cdot 1.0 =$ **21.21 psf**

Step 4: Determine the wind pressure for the communication wire

Using Table 250-2, select a wire k_z value, velocity pressure exposure coefficient:

The k_z for the communication wire is based on the height, h, of the communication wire on the structure (Rule 250C1), h = 10.8 m (35.5 ft); therefore from Table 250-2, $\mathbf{k_z} = \mathbf{1.10}$. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

$\mathbf{k_z} = 2.01 \cdot (10.8\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.017}$
$\mathbf{k_z} = 2.01 \cdot (35.5\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.017}$

Using Table 250-3, select a communication wire G_{RF} value, gust response factor:

The wire gust response factor, G_{RF}, is determined using the height of the communication wire at the structure, h = 10.8 m (35.5 ft), and the design wind span, L = 152 m (500 ft). Using Table 250-3, the communication wire $\mathbf{G_{RF}}$ equals **0.76**. The equations of Table 250-3 can be used to determine the exact value of $\mathbf{G_{RF}}$.

$B_w = 1/(1 + 0.8 \cdot 152\ \text{m}/67) = 0.355$ $E_w = 0.346 \cdot (10/10.8\ \text{m})^{1/7} = 0.342$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.342 \cdot (0.355)^{0.5})] / (1.43)^2 = \mathbf{0.758}$
$B_w = 1/(1 + 0.8 \cdot 500\ \text{ft}/220) = 0.355$ $E_w = 0.346 \cdot (33/35.5\ \text{ft})^{1/7} = 0.342$ $\mathbf{G_{RF}} = [1 + (2.7 \cdot 0.342 \cdot (0.355)^{0.5})]/ (1.43)^2 = \mathbf{0.758}$

The communication wire wind pressure, assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 1.1 \cdot 0.76 \cdot 1.0 \cdot 1.0 =$ **820 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 1.1 \cdot 0.76 \cdot 1.0 \cdot 1.0 =$ **17.34 psf**

Step 5: Determine the wind pressure for the transformer

Using Table 250-2, select a transformer k_z value, velocity pressure exposure coefficient:

The k_z for the transformer is based on the height, h, of the transformer on the structure (Rule 250C1), h = 13.9 m (45.5 ft); therefore from Table 250-2, $\mathbf{k_z}$ = **1.10**. The equations of Table 250-2 can be used to determine the exact value of $\mathbf{k_z}$.

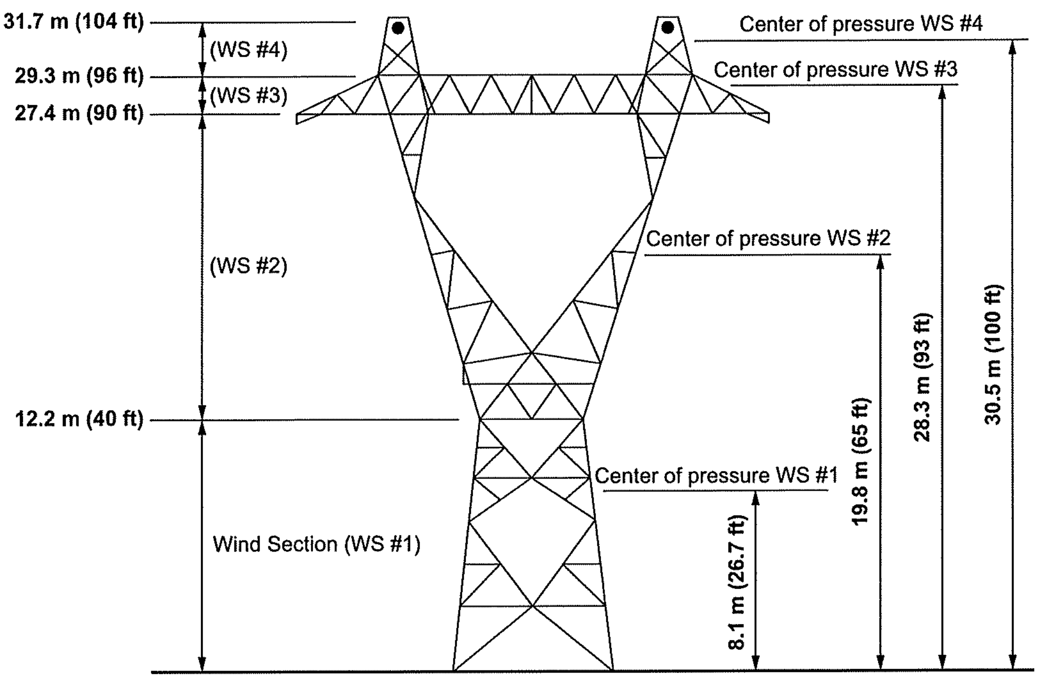
$k_z = 2.01 \cdot (13.9\ \text{m}/275\ \text{m})^{(2/9.5)} =$ **1.072**
$k_z = 2.01 \cdot (45.5\ \text{ft}/900\ \text{ft})^{(2/9.5)} =$ **1.072**

The transformer G_{RF} value, gust response factor, is 0.93, Rule 250C2.

The transformer wind pressure, assuming 40 m/s (90 mph), I and C_f equal 1.0, and the table values for k_z and G_{RF}, is

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 1.1 \cdot 0.93 \cdot 1.0 \cdot 1.0 =$ **1003 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 1.1 \cdot 0.93 \cdot 1.0 \cdot 1.0 =$ **21.21 psf**

Example 5 illustrates the application of a non-uniform wind load distribution for a lattice tower structure with a large window section and two separate groundwire support peaks. Wind loads on the window section and the groundwire peaks differ from the assumed loading model discussed in Example 3. This example suggests a method to account for loading of these specific tower features.



Example 5

Step 1: Determine assumed wind load distribution

This structure is assumed to have four different wind sections (WS), each with its specific uniform wind load.

Wind Section #1 (WS#1) was determined by engineering judgment to be the height, h, from the ground line to the tower waist, h = 12.2 m (40 ft). The center of wind pressure for WS#1 is assumed to be 2/3 the height of 12.2 m (40 ft). The second section of the tower, WS#2, is assumed to be the distance from the tower waist to the bottom of the crossarm. The center of wind pressure for WS#2 is assumed to be at the mid-height of this wind section, h = 19.8 m (65 ft). The third tower section, WS#3, is the crossarm, and its center of pressure is assumed to be at its mid-height, h = 28.3 m (93 ft). The fourth tower section, WS#4, is the groundwire peak section (both peaks will be considered together as one tower section), and its center of pressure is assumed to be at its mid-height, h = 30.5 m (100 ft).

Step 2: Determine the wind load for each structure wind section, beginning with section WS#1

Determine k_z, h = 12.2 m (40 ft), using Table 250-2, $\mathbf{k_z}$ = 1.0, using the equations:

$k_z = 2.01 \cdot (0.67 \cdot 12.2\text{ m}/275\text{ m})^{(2/9.5)} = \mathbf{0.959}$
$k_z = 2.01 \cdot (0.67 \cdot 40\text{ ft}/900\text{ ft})^{(2/9.5)} = \mathbf{0.959}$

Determine G_{RF}. The structure gust response factor is a function of the structures dynamic response. Therefore a single value of G_{RF} using the total structure height should be used on all structure wind sections. Given h = 31.7 m (104 ft), using the equations:

$B_s = 1/(1 + 0.375 \cdot 31.7\ \text{m}/67) = 0.849$ $E_s = 0.346 \cdot (10/[0.67 \cdot 31.7\ \text{m}])^{1/7} = 0.311$ $G_{RF} = [1 + (2.7 \cdot 0.311 \cdot (0.849)^{0.5})] / (1.43)^2 = \mathbf{0.867}$
$B_s = 1/(1 + 0.375 \cdot 104\ \text{ft}/220) = 0.849$ $E_s = 0.346 \cdot (33/[0.67 \cdot 104\ \text{ft}])^{1/7} = 0.311$ $G_{RF} = [1 + (2.7 \cdot 0.311 \cdot (0.849)^{0.5})] / (1.43)^2 = \mathbf{0.867}$

The structure wind pressure (uniformly distributed over WS#1) assuming 40 m/s (90 mph), I equals 1.0, and C_f equals 3.2:

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 0.959 \cdot 0.867 \cdot 1.0 \cdot 3.2 =$ **2610 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 0.959 \cdot 0.867 \cdot 1.0 \cdot 3.2 =$ **55.17 psf**

Step 3: Determine the wind load on structure wind section WS#2

In the engineer's judgment the large window of the tower presents twice the wind exposure of a normal boxed-type lattice structure. That is, the wind exposure on each side of the window would constitute two tower sections upon which wind pressure would be applied. Therefore, the judgment is made to apply a force coefficient, C_f, of 3.2 to the windward surface on each side of the window (or a single force coefficient of 6.4 to the most windward exposed surface).

Determine k_z, h = 19.8 m (65 ft), using the equations:

$k_z = 2.01 \cdot (19.8\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.16}$
$k_z = 2.01 \cdot (65\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.16}$

G_{RF} = 0.867 is applied to the overall structure, thus the structure wind pressure (uniformly distributed over WS#2) assuming 40 m/s (90 mph), I equals 1.0, and a C_f value of 6.4 will be used (double the normal 3.2 value for open lattice structures to account for the two sides of the window effectively independently subjected to wind pressures):

Wind pressure = $0.613 \cdot (40\ \text{m/s})^2 \cdot 1.16 \cdot 0.867 \cdot 1.0 \cdot 6.4 =$ **6313 newtons/m²**
Wind pressure = $0.00256 \cdot (90\ \text{mph})^2 \cdot 1.16 \cdot 0.867 \cdot 1.0 \cdot 6.4 =$ **133.47 psf**

Step 4: Determine the wind load on structure wind section WS#3

Determine k_z, h = 28.3 m (93 ft), using the equations:

$$k_z = 2.01 \cdot (28.3\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.25}$$

$$k_z = 2.01 \cdot (93\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.25}$$

The structure wind pressure (uniformly distributed over WS #3) assuming 40 m/s (90 mph), I equals 1.0 and C_f equals 3.2:

$$\text{Wind pressure} = 0.613 \cdot (40\ \text{m/s})^2 \cdot 1.25 \cdot 0.867 \cdot 1.0 \cdot 3.2 = \mathbf{3401\ newtons/m^2}$$

$$\text{Wind pressure} = 0.00256 \cdot (90\ \text{mph})^2 \cdot 1.25 \cdot 0.867 \cdot 1.0 \cdot 3.2 = \mathbf{71.91\ psf}$$

Step 5: Determine the wind load on structure wind section WS#4

Again, in the engineer's judgment the two groundwire peaks are separated such that they may be considered to be independently subjected to wind pressures, which would result in twice the wind exposure of a normal boxed-type lattice section. That is, the wind exposure on the two groundwire peak tower components would double the resulting wind load on this section of the tower. Therefore, the judgment is made to apply a force coefficient, C_f, of 3.2 to the windward surface of each peak (or a single force coefficient of 6.4 to the most windward exposed face of the peak section).

For WS#4, determine the uniformly distributed wind load. Determine, h = 30.5 m (100 ft), using the equations:

$$k_z = 2.01 \cdot (30.5\ \text{m}/275\ \text{m})^{(2/9.5)} = \mathbf{1.27}$$

$$k_z = 2.01 \cdot (100\ \text{ft}/900\ \text{ft})^{(2/9.5)} = \mathbf{1.27}$$

G_{RF} = 0.867. The structure wind pressure (uniformly distributed over WS#4) assuming 40 m/s (90 mph), I equals 1.0, and a C_f value of 6.4 will be used (double the 3.2 value for open lattice structures to account for independent wind loading of the two groundwire peaks):

$$\text{Wind pressure} = 0.613 \cdot (40\ \text{m/s})^2 \cdot 1.27 \cdot 0.867 \cdot 1.0 \cdot 6.4 = \mathbf{6912\ newtons/m^2}$$

$$\text{Wind pressure} = 0.00256 \cdot (90\ \text{mph})^2 \cdot 1.27 \cdot 0.867 \cdot 1.0 \cdot 6.4 = \mathbf{146.13\ psf}$$

Appendix D

(This Appendix is not part of Accredited Standards Committee C2, National Electrical Safety Code, 2017 Edition, and is included for information only.)

Determining maximum anticipated per-unit overvoltage factor (T) at the worksite

1. The engineering analysis used to determine and identify the TOV at the worksite should include, but not be limited to, the following:

   a. Engineering analysis of the energy sources, phase angle regulators, static var compensators, reactors, and capacitors connected to the power transmission system operating at the voltage level at which the work is being done, to determine and identify the maximum anticipated temporary overvoltage (OV), which can be produced at the worksite.

      If the capacitors and/or shunt reactors are fuse protected or switchable, the engineering analysis should be made with them in and out of service to determine the OV. The analysis should also evaluate the maximum effect on OV from the phase angle regulators and static var compensators throughout their operating range. Analysis should also evaluate the overvoltage, which results from closing of a circuit interrupting device on to a line or cable with trapped charges. Analysis of the circuit impedances to determine possibility of resonance conditions and the resulting OV should also be considered.

      The OV at the worksite should include the fundamental 60 Hz waveform combined with the major harmonics.

      Harmonic voltage should be determined by assuming simultaneous peaks for all frequencies using the limits in IEEE 519-1992™ [B35].

   b. Engineering analysis of the interrupting and isolating devices used on the power transmission system, operating at that voltage, to determine and identify the maximum anticipated switching surge (switching surge or switching impulse) (SI), which they produce.

   c. Engineering analysis of the surge reduction and protection equipment permanently connected to the power transmission system operating at that voltage to determine and identify the OV and SI levels at which they operate.

   d. Data from digital transient recorder and similar devices may be used to determine the peak value of OV and/or SI, if it has been determined from an engineering analysis and testing that the data is true and is its peaks are not limited by the equipment or equipment protection devices. Testing to determine the worst-case conditions should also be made.

2. T at the worksite is calculated by adding the peak value of OV to SI and dividing it by maximum peak voltage.

   As an example, for a line operating at 235 kV with maximum anticipated OV_{peak} corresponding to 355 kV (phase-to-phase rms) and a SI of 200 kV.

   $T = (OV_{peak} + SI) / V_{P\text{-}G\ peak}$ [in kV]

   $T = (((355 \cdot 1.414) / 1.732) + 200) / ((242 \cdot 1.414) / 1.732)$

   $T = (289.82 + 200) / 197.57$

   $T = 489.82 / 197.57 = 2.48$ or 2.5

Appendix E

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