EXHIBIT GLB-1

CURRICULUM VITAE OF

GREGORY L. BOOTH

October 11, 2017

RESUME OF GREGORY L. BOOTH, PE, PLS
President
PowerServices, Inc.
Gregory L. Booth, PLLC

Gregory L. Booth is a registered professional engineer with engineering, financial, and management services experience in the areas of utilities, industry private businesses and forensic investigation. He has been representing over 300 clients in some 40 states for more than 50 years. Mr. Booth was inducted into the North Carolina State University Electrical and Computer Engineering Alumni Hall of Fame in November of 2016 based on his accomplishments in the field of engineering.

Mr. Booth has been accepted as an expert before state and federal regulatory agencies, including the Federal Energy Regulatory Commission, the Delaware Public Service Commission, the Florida Public Service Commission, the Minnesota Department of Public Service Environmental Quality Board, the Massachusetts Attorney General Department of the Advocacy, the New Jersey Board of Public Utilities, the North Carolina Utilities Commission, the Pennsylvania Public Utility Commission, the Rhode Island Public Utilities Commission, and the Virginia State Corporation Commission. He has been accepted as an expert in both state and federal courts, including Colorado, Delaware, Florida, District of Columbia, Missouri, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, Virginia, West Virginia, Wisconsin and numerous Federal Court jurisdictions. Mr. Booth has provided expert witness services on over 500 tort case matters, and over 50 regulatory matters. Investigation and testimony experience includes areas of wholesale and retail rates, utility acquisition, territorial disputes, electric service reliability, right-of-way acquisition and impact of electromagnetic fields and evaluation of transmission line options for utility commissions.

Additionally, Mr. Booth has extensive experience serving as an expert witness before state and federal courts on matters including property damage, forensic evaluation, fire investigations, fatality, and areas of electric facility disputes and Occupational, Safety and Health Administration violations and investigations together with National Electrical Code and National Electrical Safety Code and Industry Standard compliance.

The following pages provided are the education and experience from 1963 through the present, along with courses taught and publications.

RESUME OF
GREGORY L. BOOTH, PE, PLS

Mr. Booth is a Registered Professional Engineer with engineering, financial, and management experience assisting local, state, and federal governmental units; rural electric and telephone cooperatives; investor owned utilities, industrial customers and privately owned businesses. He has extensive experience representing clients as an expert witness in regulatory proceedings, private negotiations, and litigation.

PROFESSIONAL EDUCATION:	NORTH CAROLINA STATE UNIVERSITY; Raleigh NC, Bachelor of Science, Electrical Engineering, 1969
PROFESSIONAL HONORS:	Inducted into North Carolina State University Department of Electrical and Computer Engineering Alumni Hall of Fame in November 2016.
REGISTRATIONS:	Registered as Professional Engineer in Alabama, Arizona, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Kansas, Maryland, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Commonwealth of Virginia, West Virginia, and Wisconsin Professional Land Surveyor in North Carolina Council Record with National Council of Examiners for Engineering and Surveying

EXPERIENCE:

1963-1967 Technician Booth & Associates	Transmission surveying and design assistance, substation design assistance; distribution staking; construction work plan, long-range plan, and sectionalizing study preparation assistance for many utilities, including Cape Hatteras EMC, Halifax EMC, Delaware Electric Cooperative, Prince George Electric Cooperative, A&N Electric Cooperative; assistance generation plant design, start-up, and evaluations.
1967-1973 Project Engineer Booth & Associates	Transmission line and substation design; distribution line design; long-range and construction work plans; rate studies in testimony before State and Federal commissions; power supply negotiations; all other facets of electrical engineering for utility systems and over 30 utilities in 10 states.
1973-1975 Professional Engineer Associates 1975-1994 Executive Vice President Booth & Associates	Directed five departments of Booth & Associates, Inc.; provided engineering services to electric cooperatives and other public Booth & power utilities in 23 states; provided expert testimony before state regulatory commissions on rates and reliability issues; in accident investigations and tort proceedings; transmission line routing and designs; generation plant designs; preparation and presentation of long-range and construction work plans; relay and sectionalizing studies; relay design and field start-up assistance; generation plant designs; rate and cost-of-service studies; reliability studies and analyses; filed testimony, preparation and teaching of seminars; preparation of nationally published manuals; numerous special projects for statewide organizations, including North Carolina EMC. Work was provided to over 130 utility clients in 23 states, PWC of the City of Fayetteville, NC, Cities of

Wilson, Rocky Mount and Greenville are among the utilities in which I have provided engineering services in North Carolina during this time frame. Services to industrial customers include Texfi Industries, Bridgestone Firestone, Inc and many others.

1994-2004 President Booth & Associates	Responsible for the direction of the engineering and operations of Booth & Associates, Inc. for all divisions and departments. The engineering work during this time frame has continued to be the same as during 1974 through 1993 with the addition of greater emphasis on power supply issues, including negotiating power supply contracts for clients; increased involvement in peaking generation projects; development of joint transmission projects, including wheeling agreements, power supply analyses, and power audit analyses. The work during this time frame includes providing services to over 200 utility clients across the United States, including NCEMC and NRECA.
2004-Present President Gregory L. Booth, PLLC	Providing engineering and management services to the electric industry, including planning and design. Providing forensic engineering, product evaluation, fire investigations and accident investigation, serving as an expert witness in state and federal regulatory matters and state and federal court.
2005-Present President PowerServices, Inc.	Providing engineering and management services to the electric industry, including planning and design and utility acquisition. Providing forensic engineering, product evaluation, fire investigations and accident investigation, serving as an expert witness in state and federal regulatory matters and state and federal court.

WORK AND EXPERTISE:

ELECTRIC UTILITIES:
(more than 300 clients)

- All aspects of utility planning, design and construction, from generation, transmission, substation and distribution to the end user.
- Utility acquisition expert, including providing condition assessment, system electrical and financial valuation, electrical engineering assessment, initial Work Plan and integration plans, acquisition loan funds, testimony, assessment and consulting services for numerous electric utility acquisitions. Utility clients for acquisition projects include Winter Park, FL acquisition of Progress Energy, FL, system in the City limits, A & N Electric Cooperative acquisition of the Delmarva Power & Light Virginia jurisdiction, Shenandoah Valley Electric Cooperative acquisition of Allegheny Energy Virginia jurisdiction, Rappahannock Electric Cooperative acquisition of Allegheny Energy Virginia jurisdiction, and numerous other past and currently active electric utility acquisitions.
- System studies, including long-range and short-range planning, sectionalizing studies, transmission load flow studies, system stability studies (including effects of imbalance and neutral-to-earth voltage), environmental analyses and impact studies and statements, construction work plan, power requirements studies, and feasibility studies.

- Fossil, hydro, microgrid, wind, and solar generation plan analysis, design, and construction observation.
- Transmission line design and construction observation through 230 kV overhead and underground.
- Switching station and substation design and construction observation through 230 kV.
- Distribution line design and staking, overhead and underground.
- Design of submarine cable installations. (Transmission and distribution)
- Supervisory control and data acquisition system design, installation and operation assistance.
- Load management system design, installation and operation assistance.
- Computer program development.
- Load research and alternative energy source evaluation.
- Field inspection, wiring, and testing of facilities.
- Relay and energy control center design.
- Mapping and pole inventories.
- Specialized grounding for abnormal lightning conditions.
- Ground potential rise protection.
- Protective system/relay coordination.
- Grid Modernization Plan development, regulatory testimony, and implementation
- Pole Attachment Agreements, rate design, and testimony

UTILITY OPERATIONS:

- Storm assessment services.
- Regulatory testimony on storm response.
- Storm Response Plan development.
- Operations, including outage management and Call Centers.
- Outage management and operations enhancement services and testimony.

GENERATION DESIGN / FAILURE ANALYSES:

- Intermediate and peaking generation (gas and oil fired through 400 MW).
- Peaking generation (diesel and gas through 10,000 kW)
- Wind generation.
- Solar (PV) generation.
- Hydroelectric generation.
- Microgrid, including energy storage.

TELECOMMUNICATION: UTILITIES:

- Subscriber and trunk carrier facilities design.
- Stand-by generation and DC power supplies
- DC-AC inverters for interrupted processor supplies.
- Plant design and testing.
- Fiber optics and other transmission media.
- Microwave design.
- Pole attachment designs and make-ready design.
- Pole Attachment Agreements and rental rates calculations.
- Regulatory testimony.

FINANCIAL SERVICES:

- Long-term growth analyses and venture analyses.
- Lease and cost/benefit analyses.
- Capital planning and management.
- Utility rate design and service regulations.
- Cost-of-Service studies.
- Franchise agreements.
- Corporate accounting assistance.
- Utility Commission testimony (State and Federal)

FORENSIC ENGINEERING:

- Compliance with NESC, NEC, OSHA, IEEE, ANSI, ASTM and other codes and industry standards.
- Equipment and product failure and analysis and electrical accident investigation (high and low voltage equipment).
- Stray voltage, electrical shocking, and electrocution investigations.
- Building code investigations.
- New product evaluation.
- MCC, MDP failure analysis and arc flash analysis
- Electrical fire analysis

INDUSTRIAL/ELECTRICAL ENGINEERING:

- Building design (commercial and industrial).
- Building code application and investigation. (NFPA and NEC)
- Electric thermal storage designs for heating, cooling, and hot water.
- Standby generation and peaking generation design.
- Electric service design (residential, commercial, and industrial).

INSTRUCTIONAL SEMINARS AND TEXT:

- Seminars taught on arc flash hazards and safety, including National Electrical Safety Code regulations for utilities.
- Courses taught on Distribution System Power Loss Evaluation and Management.
- Courses taught on Distribution System Protection.
- Text prepared on Distribution System Power Loss Management.
- Text prepared on Distribution System Protection.
- Seminars taught on substation design, NESC capacitor application, current limiting fuses, arresters, and many others electrical engineering subjects.
- Courses taught on accident investigations and safety.
- Courses taught on Asset Management.
- Courses taught on OSHA and Construction Safety.

TESTIMONY AS AN EXPERT:

- Concerning rate and other regulatory issues before Federal Energy Regulatory Commission and state commissions in Delaware, Florida, Maryland, Massachusetts, Minnesota, New Jersey, North Carolina, Pennsylvania, Rhode Island, and Virginia.
- Concerning property damage or personal injury before courts in Colorado, District of Columbia, Florida, Maryland, Minnesota, Missouri, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, Texas, Virginia, West Virginia, and Wisconsin.

FIELD ENGINEERING:

- Transmission line survey and plan and profile.
- Distribution line staking.
- Property surveying.
- Relay and recloser testing.
- Substation start-up testing.
- Generation acceptance and start-up testing.
- Ground resistivity testing.
- Work order inspections.
- Operation and maintenance surveys.
- Building inspection and service facility inspection.
- Construction Management
  - Generation
  - Transmission
  - Substation
  - Distribution
  - Building Electrical Installations
  - GSA construction projects
  - NASA construction projects
  - University construction projects

PROFESSIONAL ORGANIZATIONS:

a. National Society of Professional Engineers (NSPE)
b. Professional Engineers in Private Practice (PEPP)
c. National Council of Examiners for Engineering & Surveying (NCEES)
d. Professional Engineers of North Carolina (PENC)
e. National Fire Protection Association (NFPA)
f. Associate Member of the NRECA
g. NRECA Cooperative Network Advisory Committee (NRECA-CRN)
h. The Institute of Electrical and Electronics Engineers (IEEE) (Distribution sub-committee members on reliability)
i. American Standards and Testing Materials Association (ASTM)
j. Occupational Safety and Health Administration (OSHA) Certification
k. American Public Power Association (APPA)
l. American National Standards Institute (ANSI)

FEDERAL AND STATE

REGULATORY TESTIMONY

CASE LIST

October 11, 2017

Commonwealth of Virginia State Corporation Commission

Rappahannock Electric Cooperative, 247 Industrial Court, Fredericksburg, VA 22408

Case No. PUE-2009-0010 (HE)

2007

Delmarva Power & Light System Acquisition Purchase for A & N Electric Cooperative, Post Office Box 290, 21275 Cooperative Way, Tasley, VA 23441 and Old Dominion Electric Cooperative, 4201 Dominion Boulevard, Glen Allen, VA 23060

Case Nos. PUE-2007-00060, 00061, 00062, 00063, and 00065 (HE)

2009

Potomac Edison/Allegheny Energy System Acquisition Purchase for Shenandoah Valley Electric Cooperative, 147 Dinkel Ave., Hwy 257, Mt. Crawford, VA 22841

Case No. PUE-2009-00101 (HE)

2011

Virginia, Maryland & Delaware Association of Electric Cooperatives Commonwealth of Virginia at the relation of the State Corporation Commission in the Matter of Determining Appropriate Regulation of Pole Attachments and Cost Sharing in Virginia

Case No. PUE-2011-00033 (HE)

2013

Northern Virginia Electric Cooperative Pole Attachment Dispute with ComCast

PUE-2013-00055 (HE)

Delaware Public Service Commission

Delaware Electric Cooperative, Inc., Retail Rate Case and Reliability Cases

(HE)

Federal Energy Regulatory Commission

Public Works Commission of the City of Fayetteville, NC v. Carolina Power & Light Company

ER76-, ER77-, ER78, ER81-344, ER84- (HE)

2000

North Carolina Electric Membership Corporation v. Duke Energy Corporation and Duke Electric Transmission

ER01-282-000 and ER01-283-000 (HE)

Federal Energy Regulatory Commission

2000

North Carolina Electric Membership Corporation v. Virginia Electric Power Company dba North Carolina Power

EL90-26-00-000 (HE)

2015

Application for Authorization Pursuant to Section 203(a)(1)(A) and 203(a)(2) of the Federal Power Act and Request for Waivers of Certain Filing Requirements

Dkt EC15-___-000

Florida Public Service Commission (PSC)

2007

Municipal Utility Underground Consortium Pre-Filed Testimony for Storm Hardening and Undergrounding Assessment

Docket Nos. 07023-EI, 080244-EI, and 080522-EI (HE)

2007

Gulf Power Company's Storm Hardening Plan Pre-filed Testimony on Behalf of City of Panama City Beach, Florida

Florida PSC Docket No. 070299-EI (HE)

Maine Office of the Public Advocate

2016

Efficiency Maine Trust Request for Examination of Voltage Optimization Pilot Program Docket No. 2016-00162

Dkt. 2016-00162

2017

Investigation into the Designation of Non-Transmission Alternative (NTA) Coordinator

Docket No. 2016-00049 (WT)

2017

Investigation of Inclusion of Acadia Substation Investment in Rates Pertaining to Emera Maine

Docket No. 2017-00018

HE = Hearing
WT = Written Testimony

ACTIVE AND HISTORIC REGULATORY CASES BY GREGORY L. BOOTH, PE, PLS

Massachusetts Department of Public Utilities

2012

Massachusetts Office of Attorney General Commonwealth of Massachusetts Department of Public Utilities Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid Review for Storm Response and Recovery of 2008 Storm Costs

DPU 11-56 (WT) (HE)

2012

Massachusetts Office of Attorney General Western Massachusetts Electric Company, Northeast Utilities System, Review for Recovery of Storm Costs

DPU 11-102/DPU 11-102A (WT) (HE)

2013

Massachusetts Office of Attorney General Nstar Review for Recovery of Storm Costs

DPU 13-52 (WT) (HE)

2014

Massachusetts Office of Attorney General National Grid Solar Generation Phase II Program Assessment

D.P.U. 14-01 (WT)

2014

Massachusetts Office of Attorney General Western Massachusetts Electric Company, Review of Storm Recovery Reserve Cost Adjustment "SRRCA"

D.P.U. 13-135 (WT) (HE)

2016

MA Elec. Co. and Nantucket Elec. Co. d/b/a National Grid, Fitchburg Gas and Electric Light Co. d/a/a Unitil and NSTAR Elec. Co. and Western MA Elec. Co. d/b/a Eversource for Approval by the DPU of their Grid Modernization Plan

DPU 15-120, 15-121, 15-122/15-123 (HE)

2017

Nstar Electric Company and Western Massachusetts Electric Company d/b/a Eversource Energy Petition for Approval of a Performance-Based Ratemaking Mechanism and General Distribution Revenue Change

DPU 17-05 (WT) (HE)

Massachusetts Department of Public Utilities

2017

Petition of Massachusetts Electric Company and Nantucket Electric Company each d/b/a National Grid for Pre-Approval of Enhanced Vegetation Management Pilot Program

DPU 17-92

Minnesota Department of Public Service/Environmental Quality Board

Transmission Line Assessment Minnesota Department of Public Service and Minnesota Environmental Quality Board

(HE)

New Hampshire Public Utilities Commission

2004

City of Bedford v. Public Service of New Hampshire

New Jersey Public Service Commission

Sussex Rural Electric Cooperative Retail Rate Cases

(HE)

2004

New Jersey Board of Public Utilities, Focused audit of the planning, operations and maintenance practices, policies and procedures of Jersey Central Power & Light Company

Docket No. EX02120950 (HE)

2015

Jersey Central Power & Light Company ("JCP&L") and Mid-Atlantic Interstate Transmission, LLC ("MAIT") FERC 7 Factor Test Evaluation

BPU Docket No. EM15060733 (WT)

2016

Atlantic City Electric Company for Approval of Amendments to its Tariff to Provide for an Increase in Rates and Charges For Electric Service Pursuant to NJSA 48:2-21 and JJSA 48:2-21.1

DPU Docket No. ER16030252 OAL Docket No. PUC 5556-16

North Carolina Utilities Commission

Larry Eaves, et. al. v. Town of Clayton

(HE)

North Carolina Utilities Commission

Poly-Loc v. Town of Tarboro

(HE)

1990

Delora Dennis, et. al. v. Haywood EMC

E-7, Sub 474, EC-10, Sub 37, E013, Sub 151 (HE)

2001

Wake EMC Right of Way Acquisition

(TE)

2002

Progress Energy Carolinas, Inc., v. E.M. Harris, Jr. Family Limited Partnership, Edward M. Harris, III and wife Pamela M. Harris, Gene K. Harris and wife Linda Harris, Camille H. Cunnup and husband Timothy J. Cunnup Siler City Transmission Line Issues

General Court of Justice Superior Court Division, File No. 03 CVS SP 251, 252, 253, 254, 255 (WT) (HE)

2004

John Wardlaw, et. al. Interveners v. Progress Energy Carolinas

Docket No. E-2, Sub 855 (HE)

2011

Frontier Communications of the Carolinas, Inc. v. Blue Ridge Mountain Electric Membership Corporation

11-CVS-17175

2017

Jones-Onslow Electric Membership Corporation; Surry-Yadkin Electric Membership Corporation; Carteret-Craven Electric Membership Corporation; Union Electric Membership Corporation, d/b/a Union Power Cooperative v. Time Warner Cable Southeast, LLC

NCUC Docket Nos. EC-43 5888, EC-49 555, EC55 570 and EC-39 S44

2017

Blue Ridge Electric Membership Corporation v. Charter Communications Properties, LLC

Docket No EC-23, SUB 50

Pennsylvania Public Utility Commission

2004

Investigation regarding the Metropolitan Edison Company Pennsylvania Electric Company and Pennsylvania Power Company Reliability Performance

Docket No. I-00040102 (WT) (HE)

2006

Investigation regarding Pennsylvania Rural Electric Association / Allegheny Electric Cooperative Rates

Docket Nos. R-00061366, R-0061367, et. al. (WT) (HE)

2007

Wellsboro Electric Company participants Included C&T Enterprises, Inc., comprised of Wellsboro Electric Company, Claverack Rural Electric Cooperative, Inc., Tri-County Rural Electric Cooperative, Inc., and Citizens Electric

Docket No. P-2008-2020257 (WT) (HE)

2014

PREA 2014 Intervention Assistance, Analysis of Service Reliability Concerns Regarding West Pennsylvania Power Company, Pennsylvania Electric Company, Metropolitan Edison Company (First Energy Company)

Docket Nos. R-2014-2428742, -2428743, -2428744, -248745 (WT)

2014

Pennsylvania Rural Utility Commission West Penn Power Company, Pennsylvania Electric Company, Pennsylvania Power Company and Metropolitan Edison Company

R-2014-2428742, R-2014-2428743, R-2014-2428744, R-2014-2428745 (WT)

2015

MAIT and PENELEC for Authorizing the Transfer of Certain Transmission Assets from MET-Ed & PENELEC to MAIT

A-2015-2488903 (cons.)

Rhode Island Public Utilities Commission

1997

Testimony before the Rhode Island Utilities Commission, on behalf of Rhode Island Division of Public Utilities and Carriers, May 15, 1997

Docket No. 2489 (WT) (HE)

Rhode Island Public Utilities Commission

2003

Testimony before the Rhode Island Utilities Commission on behalf of Rhode Island Division of Public Utilities and Carriers, December 2003

Docket No. 2930 (WT) (HE)

2004

Issuance of Advisory Opinion to Energy Facility Siting Board Regarding The Narragansett Electric Company's Application to Relocate Transmission Lines Between Providence and East Providence, 2004

Docket No. 3564 (WT) (HE)

2006

Issuance of Advisory Opinion to Energy Facility Siting Board Regarding the Narragansett Electric Company d/b/a National Grid's Application to Construct and Alter Major Energy Facilities, 2006

Docket No. 3732 (WT) (HE)

2007

Issuance of Advisory Opinion to RIDPUC in the Matter of the Joseph Allard Fatality Involving Verizon and National Grid

2008

Issuance of Advisory Opinion to Energy Facility Siting Board Regarding the Narragansett Electric Company d/b/a National Grid's Application to Construct and Alter Major Energy Facilities, 2008

Docket No. 4029 (WT) (HE)

2010

Rhode Island Division of Public Utilities and Carriers Narragansett Tariff Investigation

Docket No. R.I.P.U.C. 4065

2010

National Grid Proposed Electric Infrastructure, Safety and Reliability Plan for FY 2012 Submitted Pursuant to R.I.G.L. § 39-1-27.7.1

Docket No. 4218 (WT) (HE)

2012

National Grid Electric FY 2013 Electric Infrastructure, Safety and Reliability Plan

Docket No. 4307 (WT) (HE)

Rhode Island Public Utilities Commission

2012

National Grid Hurricane Irene Response Assessment, 2012

Docket No. D-11-94 (WT) (HE)

2012

Public Utilities Commission Review of Storm Contingency Funds of Electric Utilities

Docket No. 2509 (WT) (HE)

2012

Commission's Investigation Relating to Stray and Contact Voltage

Docket No. 4237 (WT)

2012

Rhode Island Public Utilities Commission Interstate Reliability Assessment

Docket No. 4360 (WT) (HE)

2012

National Grid Electric Infrastructure, Safety, and Reliability Plan for 2014

Docket No. 4382 (WT) (HE)

2014

National Grid Electric Infrastructure, Safety, and Reliability Plan 2015 Proposal

Docket No. 4473 (WT) (HE)

2014

National Grid's FY 2016 Electric Infrastructure, Safety and Reliability Plan

Docket No. 4539 (WT) (HE)

2015

Division's Investigation into Verizon's Vegetation Management Practices

2015

Wind Energy Development, LLC (WED) and ACP Land, LLC Petition for Dispute Resolution Relating to Interconnection

Docket No. 4483 (WT)

Rhode Island Public Utilities Commission

2015

National Grid Electric Infrastructure, Safety, and Reliability Plan FY 2017

Docket No. 4592 (WT) (HE)

2016

PUC Advisory Opinion Regarding Need of The Narragansett Electric Co. d/b/a National Grid to Construct and Alter Certain Transmission Components in the Towns of Portsmouth and Middletown (Aquidneck Island Reliability Project)

Docket No. 4614

2016

National Grid Electric Infrastructure, Safety, and Reliability Plan FY 2018

Docket No. 4682 (WT)

2017

National Grid Electric Infrastructure, Safety, and Reliability Plan FY 2019

CURRENT & HISTORICAL CLIENT LISTS

October 11, 2017

Partial List of Historical Electrical Utility Clients

Client Name	*City*	*State*
4 CES/CEEC	Seymour Johnson AFB	NC
A&N Electric Cooperative	Parksley	VA
ACRES International Corporation	Grand Forks	ND
Action Sensors, Inc.	Wendell	NC
Adams Rural Electric Cooperative	West Union	OH
AFL Telecommunications		NC
Alaska 220 Communications	Anchorage	AK
Alachua, City of	Alachua	FL
Alabama Power Company	Birmingham	AL
Albemarle Electric Membership Corporation	Hertford	NC
Alcoa Fujikura, Ltd.	Spartanburg	SC
Allegheny Electric Cooperative	Harrisburg	PA
Alleghany Power Energy	Greensburg	PA
Altahama Electric Membership Corporation	Lyons	GA
Alternative Energy Corporation	RTP	NC
American Public Power Association	Washington	DC
American Telecommunications	Raleigh	NC
Apex Communications, LLC	Wynne	AR
Apex, Town of	Apex	NC
Arkansas Electric Cooperative, Inc.	Little Rock	AR
AT&T	Durham	NC
Atlantic Power Generation	Charlotte	NC
Ayden, Town of	Ayden	NC
Bailey & Dixon	Raleigh	NC
Baker, Jenkins, Jones & Daly	Ahoskie	NC
BARC Electric Cooperative	Millboro	VA
Barnhill Contracting Company	Tarboro	NC
Bath Electric, Gas & Water	Bath	NC
Battle, Winslow, Scott & Wiley	Rocky Mount	NC
Beckwith Power Systems	North Versailles	PA
Bedford, City of	Bedford	VA
Belhaven, Town of	Belhaven	NC
Bellsouth Mobility DCS	Raleigh	NC
Bennettsville, City of	Bennettsville	SC
Benson, Town of	Benson	NC
Biltmore Dairy Farms, Inc.	Asheville	NC
Black Creek, Town of	Black Creek	NC
Blountstown, City of	Blountstown	FL
Blue Ridge Electric Cooperative	Pickens	SC
Blue Ridge Electric Membership Corporation	Lenoir	NC
Boulder, City of	Boulder	CO
Brantley & Wilkerson, PC	Montgomery	AL
Brunswick Electric Membership Corporation	Shallotte	NC

Client Name	*City*	*State*
Burlington-Northern Railroad	St. Paul	MN
Burroughs Wellcome Company	RTP	NC
Bushnell, City of	Bushnell	FL
Calpine Operations Services (Calpine Power)		
Cape Hatteras EMC	Buxton	NC
Carolina Power & Light	Raleigh	NC
Carroll Electric Cooperative	Carrollton	OH
Carteret Craven Electric Cooperative	Morehead City	NC
Central Electric Cooperative, Inc.	Parker	PA
Central Electric Membership Corporation	Sanford	NC
Central Georgia Electric Membership Corporation	Jackson	GA
Central Virginia Electric Cooperative	Lovingston	VA
Centura Bank	Rocky Mount	NC
Charter Communications	Holly Ridge	NC
Chattahoochee, City of	Chattahoochee	FL
Cherry Hospital – DHR	Goldsboro	NC
Choptank Electric Cooperative	Denton	MD
Claverack Rural Electric Cooperative	Wysox	PA
Clayton, Town of	Clayton	NC
Clemson University	Clemson	SC
Clewiston, City of	Clewiston	FL
CNA Insurance Companies	Rockville	MD
Cobb Electric Membership Corporation	Marietta	GA
Coconut Creek, City of	Coconut Creek	FL
Columbus Water Works	Columbus	GA
Community Electric Cooperative	Windsor	VA
Cornelius & Huntersville	Huntersville	NC
Continental Cooperative Services	Harrisburg	PA
Cornice Engineering, Inc.	Pagosa Springs	CO
Craig-Botetourt Electric Cooperative	New Castle	VA
CP&L Area Cooperatives		NC
Crawford & Company	Raleigh	NC
Crescent Electric Membership Corporation	Statesville	NC
C&T Enterprises		PA
Dalton Utilities	Dalton	GA
Danvers, Town of	Danvers	MA
Danville, City of	Danville	VA
Davidson Water Cooperative	Welcome	NC
Delaware County Electric Cooperative	Delhi	NY
Delaware Division of Parks & Recreation	Dover	DE
Delaware Electric Cooperative	Greenwood	DE
Depcom Power		
Dover, City of	Dover	DE
Drexel, Town of	Drexel	NC
Duke Energy Progress	Raleigh	NC
East Carolina University	Greenville	NC

Client Name	*City*	*State*
East Kentucky Power Cooperative	Winchester	KY
Easton Utilities Commission	Easton	MD
Eden, City of	Eden	NC
Edenton, Town of	Edenton	NC
Edgecombe Martin County Electric Membership Corp.	Tarboro	NC
Electric Cooperative of SC	Cayce	SC
Electricities of NC, Inc.	Raleigh	NC
Elizabeth City, City of	Elizabeth City	NC
EMC Technologies	Raleigh	NC
EnergyUnited	Statesville	NC
Enfield, Town of	Enfield	NC
Enron Wind Corporation	Tehachapi	CA
Exelon Business Services		
Farmville, Town of	Farmville	NC
Flint Energies	Warner Robins	GA
Florida Keys Electric Cooperative Association, Inc.	Tavernier	FL
Florida Municipal Electric Association	Tallahassee	FL
Florida Municipal Power Agency	Orlando	FL
Fort-Bragg – USA	Fort Bragg	NC
Fort Lauderdale, City of	Fort Lauderdale	FL
Fort Meade, City of	Fort Meade	FL
Fort Pierce Utilities	Fort Pierce	FL
Four County Electric Membership Corporation	Burgaw	NC
Fox Islands Electric Cooperative	Vinalhaven	ME
French Broad Electric Membership Corporation	Marshall	NC
Fremont, Town of	Fremont	NC
Georgia Consumers Utility Council	Atlanta	GA
Georgia Power	Union City	GA
Gillette, City of	Gillette	WY
Great River Energy	Maple Grove	MN
Green Cove Springs, City of	Green Cove Springs	FL
Greenville Utilities	Greenville	NC
Greer, SC Comm. Of Public Works	Greer	SC
Greystone Power Corporation	Douglasville	GA
Groton Utilities	Groton	CT
Guernsey-Muskingum Electric Cooperative	New Concord	NH
Habersham Electric Membership Corporation	Clarksville	GA
Halifax Electric Membership Corporation	Enfield	NC
Hancock-Wood Electric Cooperative	N. Baltimore	OH
Harkers Island Electric Membership Corporation	Harkers Island	NC
Harnett County Wastewater	Lillington	NC
Harron Communications	Frazer	PA
Hart Electric Membership Corporation	Hartwell	GA
Havana, Town of	Havana	FL
Haynes Electric Utility Company	Asheville	NC
Haywood Electric Membership Corporation	Waynesville	NC

Client Name	*City*	*State*
Hertford, Town of	Hertford	NC
High Point, City of	High Point	NC
High Point, Regional Hospital	High Point	NC
Hobgood, Town of	Hobgood	NC
Hookerton, Town of	Hookerton	NC
Jacksonville Beach, City of	Jacksonville Beach	FL
Joe Wheeler Electric Membership Corporation	Trinity	AL
Jones-Onslow Electric Membership Corporation	Jacksonville	NC
Jupiter Inlet Colony	Jupiter Inlet	FL
Kenergy	Owensboro	KY
Keys Energy Services	Key West	FL
Kinston, City of	Kinston	NC
LaGrange, Town of	LaGrange	NC
Laurinburg, City of	Laurinburg	FL
Lee County Electric Cooperative		FL
Lewes, DE Board of Public Works	Lewes	DE
Lewis County Rural Electric Cooperative	Lewiston	MO
Lexington Utilities	Lexington	NC
Lexington, City of	Lexington	NC
Lookout Windpower, LLC		PA
Louisburg, Town of	Louisburg	NC
Lucama, City of	Lucama	NC
Lumbee River MEC	Red Springs	NC
Lumberton, City of	Lumberton	NC
Lynches River Electric Cooperative	Pageland	SC
Madison, Borough of	Madison	NJ
Maine Department of Public Advocate		ME
Maine Public Service Company	Presque Isle	ME
Manassas, City of	Manassas	VA
Martinsville, City of	Martinsville	VA
Massachusetts Office of the Attorney General		MA
Mebane, City of	Mebane	NC
Mecklenburg Electric Cooperative	Chase City	VA
Middle Georgia Electric Membership Corporation	Rochelle	GA
Milford, City of	Milford	DE
Minnesota DPS	St. Paul	MN
Mississippi Power	Gulfport	MS
Mitchell Electric Membership Corporation	Camilla	GA
MN Planning/Environmental	St. Paul	MN
Monroe, City of	Monroe	NC
Morganton, City of	Morganton	NC
Municipal Gas Group	Wilson	NC
National Rural Telecom Cooperative	Herndon	VA
National Spinning Co., Inc.	Washington	NC
New Bern, City of	New Bern	NC
Newberry, City of	Newberry	NC

Client Name	*City*	*State*
New Enterprise Rural Electric Cooperative	New Enterprise	PA
New Hampshire Electric Cooperative	Plymouth	NH
North Carolina AT&T State University	Greensboro	NC
North Carolina Association of Electric Cooperatives	Raleigh	NC
North Carolina Eastern Municipal Power Agency	Raleigh	NC
North Carolina Electric Membership Corporation	Raleigh	NC
North Carolina League of Municipalities	Raleigh	NC
North Carolina Rural Telecommunications Cooperative	Enfield	NC
North Carolina State University	Raleigh	NC
North Georgia Electric Membership Corporation	Dalton	GA
North Miami, City of	Miami	FL
Northern Neck Electric Cooperative	Warsaw	VA
Northern Virginia Electric Cooperative	Gainesville	VA
Northfield Electric Department	Northfield	VT
Northwest Public Power Association	Vancouver	WA
Northwestern Rural Electric Cooperative Association	Cambridge Springs	PA
NRECA	Arlington	VA
Ohio Rural Electric Cooperative, Inc.	Columbus	OH
Old Dominion Electric Cooperative	Glen Allen	VA
Ostego Electric Cooperative	Hartwick	NY
Palm Beach, Town of	Palm Beach	FL
Panama City Beach	Panama City	FL
Pee Dee Electric Cooperative	Darlington	SC
Pee Dee Electric Membership Corporation	Wadesboro	NC
Pennsylvania Rural Electric Association	Harrisburg	PA
Perkasie, Borough of	Perkasie	PA
Piedmont Electric Membership Corporation	Hillsborough	NC
Pineville, Town of	Pineville	NC
Pitt & Greene Electric Membership Corporation	Farmville	NC
Pompano Beach, City of	Pompano Beach	FL
Potomac Electric Power Company	Washington	DC
Prince George Electric Cooperative	Waverly	VA
Progress Energy	Raleigh	NC
PWC of the City of Fayetteville	Fayetteville	NC
Quincy, City of	Quincy	FL
Randolph Electric Membership Corporation	Asheboro	NC
Rappahannock Electric Cooperative	Fredericksburg	VA
REA Energy Cooperative (SW Central)	Indiana	PA
Red Springs, Town of	Red Springs	NC
RI Division of Public Utilities and Carriers	Warwick	RI
Roanoke Electric Cooperative	Rich Square	NC
Robersonville, Town of	Robersonville	NC
Rocky Mount, City of	Rocky Mount	NC
Roxboro, City of	Roxboro	NC
Rutherford Electric Membership Corporation	Forest City	NC
Sacramento Municipal Utility District	Sacramento	CA

Client Name	*City*	*State*
Salem, City of	Salem	VA
Sandhills Utility Services, LLC	Red Springs	NC
Santee Cooper	Myrtle Beach	SC
Satilla Rural Electric Membership Corporation	Alma	GA
Sawnee Electric Membership Corporation	Cumming	GA
South Carolina Association of Municipal Power Systems	Columbia	SC
Scotland Neck, Town of	Scotland Neck	NC
Seaford, Town of	Seaford	DE
Selma, Town of	Selma	NC
Seneca, City of	Seneca	SC
Sharpsburg, Town of	Sharpsburg	NC
Shenandoah Valley Electric Cooperative	Mt. Crawford	VA
SMECO	Hughesville	MD
Smithfield, Town of	Smithfield	NC
Snapping Shoals Electric Membership Corporation	Covington	GA
Somerset Rural Electric Cooperative	Somerset	PA
South Daytona, City of	South Daytona	FL
South Mississippi Electric Power Association	Hattiesburg	MS
South River Electric Membership Corporation	Dunn	NC
Southport, City of	Southport	NC
Southside Electric Cooperative	Crewe	VA
Stantonsburg, Town of	Stantonsburg	NC
Starke, City of	Starke	FL
Steuben Rural Electric Cooperative	Bath	NY
STS Hydro Power Limited	Northbrook	IL
Sullivan County Rural Electric Cooperative	Forksville	PA
Sulphur Springs Valley Electric Membership Corp.	Willcox	AZ
Sumter Electric Cooperative		FL
Surry-Yadkin Electric Membership Corporation	Dobson	NC
Sussex Rural Electric Cooperative	Sussex	NJ
Talquin Electric Cooperative, Inc.	Quincy	FL
Tarboro, Town of	Tarboro	NC
Tideland Electric Membership Corporation	Pantego	NC
Tri-County Electric Membership Corporation	Dudley	NC
Tri-County Electric Membership Corporation	Lafayette	TN
Tri-County Rural Electric Cooperative	Mansfield	PA
TVPPA	Chattanooga	TN
UNC – Asheville	Asheville	NC
UNC – Chapel Hill	Chapel Hill	NC
UNC – Charlotte	Charlotte	NC
UNC – Greensboro	Greensboro	NC
Union Electric Membership Corporation	Monroe	NC
United Electric Cooperative	DuBois	PA
US Generating Company	Bethesda	MD
VA, MD & DE Association of Electric Cooperatives	Glen Allen	VA
Valley Rural Electric Cooperative	Huntington	PA

Client Name	*City*	*State*
Vanceburg, City of	Vanceburg	KY
Vero Beach, City of	Vero Beach	FL
Wake Electric Membership Corporation	Wake Forest	NC
Wake Forest, Town of	Wake Forest	NC
Walstonburg, Town of	Walstonburg	NC
Warren Electric Membership Corporation	Youngsville	PA
Washington Electric Cooperative	E. Montpelier	VT
Washington Electric Membership Corporation	Sandersville	GA
Washington, City of	Washington	NC
Waynesville, Town of	Waynesville	NC
Wellsboro Electric Company	Wellsboro	PA
West Virginia Power Company	Lewisburg	WV
Western Carolina University	Cullowhee	NC
Wilmington, City of	Wilmington	NC
Wilson, City of	Wilson	NC
Windsor, Town of	Windsor	NC
Winter Park, City of	Winter Park	FL
Winterville, Town of	Winterville	NC

Partial List of Historical Industrial Clients

Client Name	*City*	*State*
AT&T	Durham	NC
Atlantic Power Generation	Charlotte	NC
Beckwith Power Systems	North Versailles	PA
Black & Decker	Tarboro	NC
Bridgestone/Firestone (BFS)	Wilson	NC
Burroughs Wellcome Company	RTP	NC
Caswell Center	Kinston	NC
Centura Bank	Rocky Mount	NC
Centex Construction	Atlanta	GA
Charter Communications	Surf City	NC
Cherry Hospital – DHR	Goldsboro	NC
Clapp Research Associates	Raleigh	NC
Clark Substations, LLC	Calera	AL
Cornice Engineering, Inc.	Pagosa Springs	CO
Data Comlink, Inc.	Sandersville	GA
Design Dimensions, Inc.	Raleigh	NC
Dolan and Dolan	Newton	NJ
Dupaco	Kinston	NC
Drucker & Falk	Raleigh	NC
E&R Construction	Kinston	NC
Empire of Carolina	Tarboro	NC
Farmville Water and Wastewater Systems	Farmville	NC
Frigidaire	Kinston	NC
Fontaine Fifth Wheel	Birmingham	AL
Fonville-Morrisey	Raleigh	NC
Fort Bragg	Fort Bragg	NC
General Electric	Fairfield	CT
Glenoit Industries	Tarboro	NC
Goldsboro, City of	Goldsboro	NC
Cherry Hospital DHR	Goldsboro	NC
Gregory Poole Power Systems	Raleigh	NC
Harris Development Corp.	Wilson	NC
Hesco, Incorporated	Smithfield	NC
High Point Regional Hospital	High Point	NC
Honeywell	Fort Bragg	NC
Jag Management, Inc.	Raleigh	NC
KCI Technologies, Inc.	Raleigh	NC
Kelly Springfield Tire Co.	Fayetteville	NC
Kinston City Hall	Kinston	NC
Larry A. Blattenberger, Inc.	Martinsburg	PA
Lenior, City of	Lenoir	NC
Lenoir Memorial Hospital	Kinston	NC
Lewes, DE, City of	Lewes	DE
Maida Vale, LLC	Raleigh	NC

Client Name	*City*	*State*
National Fruit Product Company		VA
NC Department of Human Resources	Raleigh	NC
NC Department of Transportation	Raleigh	NC
NC Division of Mental Health	Raleigh	NC
NC Licensing Board – General Contractor	Raleigh	NC
NC School of Deaf	Raleigh	NC
NC State Construction Office	Raleigh	NC
New Hanover County	Wilmington	NC
North Hills PBX	Raleigh	NC
Nucor Steel	Charlotte	NC
Pitt County Memorial Hospital	Greensville	NC
Pope Air Force Base	Pope AFB	NC
Power Delivery Associates	Smyrna	GA
PS & W Engineering	Cary	NC
Rail-Veyor Global Technologies, Inc.		
Raleigh, City of	Raleigh	NC
Rocky Mount City Hall	Rocky Mount	NC
Sara Lee Corporation	Tarboro	NC
Seymour-Johnson Air Force Base	Goldsboro	NC
Talisman Partners, Inc. (now Earthtech)	Englewood	CO
Tantalus Systems, Corp.	Burnaby, BC	Canada
Tarboro Elementary School	Tarboro	NC
Tarboro High School	Tarboro	NC
Tarboro Water and Wastewater Systems	Tarboro	NC
Teligent, Inc.	Alpharetta	GA
Texfi Industries	Fayetteville	NC
The West Co.	Kinston	NC
Time Warner Cable	Newport	NC
Transco	Charlottesville	VA
US Postal Services (GSA)	Raleigh	NC
Utility Engineering Services	Jackson	TN
Volvo Data North America	Greensboro	NC
Wake County Parks & Recreation	Raleigh	NC
West Company	Kinston	NC
Western North Carolina School for the Deaf	Morganton	NC
Williams Energy Group	Tulsa	OK
Zenith Controls, Inc.	Chicago	IL

Partial List of Historical Law Firm Clients

Client Name	City	State
Abrams & Abrams, P.A.	Raleigh	NC
Abrams & Abrams, PA	Raleigh	NC
Adams, Hendon, Carson, Crow & Saenger, P.A.	Asheville	NC
Allen & Gooch	Lafayette	LA
Andrews Law Group	Tampa	FL
Bailey & Dixon LLP	Raleigh	NC
Baker & Abraham, PC	Boston	MA
Baker Law Firm, PA	Wilmington	NC
Baker, Jenkins, Jones & Daly PA	Ahoskie	NC
Baker, Jenkins, Jones, Murray, Askew & Carter, PA		
Balch & Bingham LLP	Birmingham	AL
Barnes Law Firm, LLC	Kansas City	MO
Barr, Murman, Tonelli, Slother & Sleet	Tampa	FL
Bartimus, Frickleton, Robertson & Gorny	Leawood	KS
Bartimus, Frickleton, Robertson & Goza, P.C.	Leawood	KS
Beasley Allen	Montgomery	AL
Beaver, Holt, Richardson, Sternlicht, Burge & Glazier, PA	Fayetteville	NC
Berkley Net Underwriters, LLC	Woodbridge	VA
Berman & Simmons	Lewiston	ME
Berman | Sobin | Gross | Feldman & Darby, LLP	Gaithersburgh	MD
Beskind and Rudolph, P.A.	Chapel Hill	NC
Bordas, Bordas & Jividen	Wheeling	WV
Breit Drescher Imprevento & Walker	Virginia Beach	VA
Bretz & Young, L.L.C	Hutchinson	KS
Brian G. Miller Co., P.A.	Columbus	OH
Britcher, Leone and Roth, LLC	Glen Rock	NJ
Buck, Danaher, Ryan & McGlenn	Elmira	NY
Campbell Campbell Edwards and Conroy	Boston	MA
Campbell, Campbell Edwards & Conroy	Boston	MA
Carey Leisure & Neal	Clearwater	FL

Client Name	*City*	*State*
Carolina Adjusters	Smithfield	NC
Chappell, Smith and Arden	Columbia	SC
Civille & Tang, PLLC	Hagatna	GU
Coleman, Bernholz, Dickerson, Bernholz, Gledhill, Hargrave	Chapel Hill	NC
Colombo Law	Columbus	OH
Copeland, Cook, Taylor & Bush, PA	Ridgeland	MS
Couch & Taibi	Durham	NC
Cozen O' Connor	Charlotte	NC
Crisp, Davis, Page & Currin, LLP	Raleigh	NC
Crisp, Page & Currin LLP	Raleigh	NC
Daniel & Daniel	Yanceyville	NC
Daniel, Medley & Kirby, P.C.	Danville	VA
David A. Vukelja, PA	Ormond Beach	FL
Davis & Lumsden PA	Beaufort	NC
DeVore & Acton, PA	Charlotte	NC
Devore, Acton & Stafford, PA	Charlotte	NC
Dickie, McCamey & Chilcote, P.C.	Charlotte	NC
Dollar Burns & Becker	Kansas City	MO
Dugan, Brinkmann, Maginnis & Pace	Philadelphia	PA
Edmonds Cole Law Firm, PC	Oklahoma City	OK
Edward M. Ricci Law Firm	West Palm Beach	FL
Edwards, Kirby & Holt, LLP	Raleigh	NC
Eppes & Plumblee, P.A.	Greenville	SC
Ervin & Gates	Charlotte	NC
Faulkner & Boyce, PC	New London	CT
Federal Reserve Bank of Richmond, VA	Richmond	VA
Fiore, Krause, Crogan & Lopez	Owings Mills	MD
Forensic Engineering, Inc.	Raleigh	NC
Frank M. Wilson, PC	Montgomery	AL
Freidman, Sissman & Heaton	Memphis	TN
Friday, Eldredge & Clark	Little Rock	AZ

Client Name	*City*	*State*
Frohilich, Gordon & Beason Law Firm	Port Charles	FL
Gallivan, White & Boyd, P.A.	Greenville	SC
Gary Harris Attorneys At Law	Orlando	FL
Glascock, Gardy & Salvage	Suffolk	VA
Godin Geretty & Puntillo	Kenosha	WI
Godwin, Morris, Laurenzi & Bloomfield	Memphis	TN
Gough, Skipworth, Summers, Eves & Travett	Rochester	NY
Granger, Santry, Mitchell & Heath PA	Tallahassee	FL
Grossman, Roth & Partridge	Sarasota	FL
Habush, Habush, Davis & Rottier, SC	Rhinelander	WI
Hall Ansley, P.C.	Springfield	MO
Harrison, White, Smtih & Coggins, P.C.	Spartanburg	SC
Haynsworth Sinkler Boyd, P.A.	Greenville	SC
Hedrick & Blackwell, LLP	Wilmington	NC
Hedrick, Eatman, Gardner & Kincheloe	Charlotte	NC
Herzfeld & Rubin, P.C.	New York	NY
Hogue, Hill, Jones, Nash & Lynch	Wilmington	NC
Holden & Carr	Tulsa	OK
Holt Sherlin LLP	Raleigh	NC
Hoover Penrod, PLC	Harrrisonburg	VA
Hutchens Law Firm	Fayetteville	NC
Hux, Livermon & Armstrong, LLP	Enfield	NC
Irigonegaray & Associates	Topeka	KS
Jacquart & Lowe, S.C.	Milwaukee	WI
James McElroy & Diehl, P.A.	Charlotte	NC
Jensen, McGrath, & Podgorny, PA	Research Triangle Park	NC
Jernigan Law Firm	Raleigh	NC
Joel H. Holt, Esq., PC	Christiansted	VI
John Gehlhausen Attorney at Law	Lamar	CO
Johnson & Ward	Atlanta	GA
Jose G. Rodriguez, PA	West Palm Beach	FL

Client Name	*City*	*State*
Kaplan, Gilpin & Associates, LLC	Charlotte	NC
Kassel Law	Columbia	SC
Katzman, Wasserman, Bennardini & Rubinstein, PA	Plantation	FL
Kaufman & Canoles	Richmond	VA
Key & Tatel	Roanoke	VA
Kilpatrick Stockton LLP	Raleigh	NC
La Capra Associates, Inc.	Boston	MA
Langdon & Emison	Lexington	MO
Langdon and Emison	Lexington	MO
Lanzotti & Rau LLC	Cape Girardeau	MO
Larry Leake Attorney At Law	Marshall	NC
Law Offices of Peter A. Jouras, Jr.	Overland Park	KS
Law Offices of Rohn and Carpenter, LLC	Christiansted	VI
Law Offices of William M. Jeter, PLLC	Memphis	TN
LeClair Ryan	Glen Allen	VI
Levinson Axelrod, P.A.	Edison	NJ
Lichtenstein Fishwick PPL	Roanoke	VA
Lucas, Bryant & Denning, PA	Selma	NC
Lytal, Reiter, Ivey & Fronrath	West Palm Beach	FL
Maher & Associates	Towson	MD
Margolis and Velassco	Chicago	IL
Mark C. Tanenbaum, PA	Charleston	SC
Mark C. Tanenbaum, PA	Charleston	SC
Martin and Jones, PLLC	Raleigh	NC
Martin, Jean & Jackson	Ponca City	OK
Massachusetts Attorney General Office	Boston	MA
McAngus Goudelock & Courie	Raleigh	NC
McAngus, Goudelock & Courie, LLC	Raleigh	NC
McCoy, Weaver, Wiggins, Cleveland & Raper	Fayetteville	NC
McCoy, Weaver, Wiggins, Cleveland & Raper PLLC	Fayetteville	NC
McGougan, Wright, Worley, Harper & Bullard, LLP	Tabor City	NC

Client Name	*City*	*State*
McGuire Woods, LLP	Richmond	VA
McNess, Wallace & Nurick LLC	Harrisburg	PA
Michael F. Amezaga, P.A.	West Palm Beach	FL
Michie Hamlett Lowry Rasmussen & Tweel PLLC	Charlottesville	VA
Miles & Stockbridge, PC	Baltimore	MD
Montgomery & Larson, LLP	West Palm Beach	FL
Moore & Van Allen, PLLC	Durham	NC
Morton and Gettys	Rock Hill	SC
Narron, O'Hale, Whittington & Woodruff PA	Benson	NC
Nelson, Mullins, Riley & Scarborough LLP	Raleigh	NC
Nexsen Pruet	Greensboro	NC
Odem & Groves PC	Charlotte	NC
Offices of David B. Mishael, PA	Miami	FL
Offices of Ronald C. Jessamy, PLLC	Washington	DC
Orr & Reno, P.A.	Concord	NH
Panter, Panter & Sampedro	Miami	FL
Parker Poe	Raleigh	NC
Parker Poe Law Firm	Spartanburg	SC
Parr Richey Obremskey Frandsen & Patterson	Lebanon	IN
Patla, Staus, Robinson & Moore, P.A.	Asheville	NC
Patrick C. Fire Law Offices	Boardman	OH
Patrick H. Dekle, P.A.	Tampa	FL
Patterson, Dilthey, Clay, Bryson & Anderson, LLP	Raleigh	NC
Patterson, Dilthey, Clay, Cranfill, Sumner & Hartzog	Raleigh	NC
Patterson, Harkavy & Lawrence LLP	Raleigh	NC
Penry Riemann PLLC	Raleigh	NC
Peter Perlman Law Offices PSC	Lexington	KY
Peters, Murdaugh, Parker, Eltzroth & Detrick	Hampton	SC
Peters, Murdough, Parker, Eltsroth & Detrick	Hampton	SC
Pittman, Germany, Roberts & Welsh LLP	Jackson	MS
Podgorny Law, PA	Durham	NC

Client Name	City	State
Pope & Tart	Dunn	NC
Poyner & Spruill, LLP	Rocky Mount	NC
Pulley, Watson, King & Lischer, P.A.	Durham	NC
Ragsdale Liggett	Raleigh	NC
Rainwater Holt & Sexton, PA	Little Rock	AR
Randles, Mata & Brown, LLC	Kansas City	MO
Reid, Lewis Deese & Nance	Fayetteville	NC
Ricci & Leopold, P.A.	Palm Beach Gardens	FL
Richardson, Patrick, Westbrook & Brickman, LLC	Barnwell	SC
Robert D. Douglass Attorney at Law	Indiana	PA
Rountree Losee, LLP	Wilmington	NC
Sandler & Marchesini, PC	Philadelphia	PA
Sanford Thompson, PLLC	Raleigh	NC
Saperston & Day, PC	Buffalo	NY
Scherffius, Ballard, Still & Ayers, LLP	Atlanta	GA
Schoen Walton Teleken & Foster, LLC		
Schultz Law, LLC	Conshohocken	PA
Schwed, Adams, Sobel & McGinley, P.A.	Palm Beach Gardens	FL
Scott T. Kimmel Attorney at Law	Lighthouse Point	FL
Searcy, Denney, Scarola, Barnhart & Shipley, PA	W. Palm Beach	FL
Shapiro, Cooper, Lewis & Appleton, PC	Virginia Beach	VA
Silverstein, Silverstein & Silverstein, PA	Aventura	FL
Simon & Bocksch	Miami	FL
Simon Passanante, PC	St. Louis	MO
Simpson Boyd & Powers	Decatur	TX
Smith & Duggan LLC	Lincoln	MA
Smith & Duggan, LLP	Boston	MA
Smith, Anderson, Blount, Dorsett, Mitchell & Jernigan, LLP	Raleigh	NC
Smith, Helms, Muliss & Moore	Raleigh	NC
Smith, Helms, Mulliss & Moore, LLP	Charlotte	NC
Smith, Patterson, Follin, Curtis, James & Haravey	Greensboro	NC

Client Name	*City*	*State*
Sommer, Olk Schroeder & Payant	Rhinelander	WI
Sommer, Olk, Schroeder & Payant, LLP	Rhinelander	WI
Spivey Law Firm	Ft. Myers	FL
Stites & Hopkins	Kansas City	MO
Stoner, Bowers, Gray & McDonald, P.A.	Lexington	NC
Strassburger McKenna Gutnick & Gefsky	Pittsburgh	PA
Sumrel ,Sugg, Carmichael, Hicks & Hart	New Bern	NC
Taraska, Grower, Unger & Ketcham, PA	Orlando	FL
Taylor, Day, Grimm, Boyd & Johnson	Jacksonville	FL
The Accurso Law Firm	Kansas City	MO
The Becker Law Firm	Cleveland	OH
The Chandler Law Group	Charlottsville	VA
The Kuhlman Law Firm, LLC	Kansas City	MO
The Redfearn Law Firm, P.C.	Independence	MO
The Wilbur C. Smith, III Law Firm, LLC	Fort Myers	FL
Thompson, Smyth & Cioffi, LLP	Raleigh	NC
Throp, Fuller & Slifkin, P.A.	Raleigh	NC
Timothy D. Welbourne Attorney at Law	Wilkesboro	NC
Troutman Sanders LLP	Raleigh	NC
Turner & Sweeny	Kansas City	MO
Twiggs, Abrams, Strickland & Trehy, P.A.	Raleigh	NC
Twiggs, Abrams, Strickland & Trey, PA	Raleigh	NC
Vandeventer Black LLP	Raleigh	NC
W. Osmond Smith III Attorney at Law	Yanceyville	NC
Walters Bender Strohbehn & Vaughan, PC	Kansas City	MO
Ward & Smith, PA	Greenville	NC
Warren & McGraw, LLC	Blue Bell	PA
Warshafsky, Rotter, Tarnoff & Block, S.C.	Milwaukee	WI
Warshauer Poe & Thornton, PC	Atlanta	GA
Whitacker, Mudd, Luke & Wells, LLC	Birmingham	AL
Whitesides & Kenny	Gastonia	NC

Client Name	*City*	*State*
Wilkins Frohlich, PA	Port Charlotte	FL
Williams & Connolly LLP	Washington	DC
Williamson & Lavecchia LC	Richmond	VA
Wilson, Frame, Metheney Attorneys & Counselors at Law	Morgantown	WV
Wilson, Garber & Small	Orlando	FL
Winner, Wixson & Pernitz	Madison	WI
Womble Carlyle Sandridge & Rice	Winston-Salem	NC
Womble Carlyle Sandridge & Rice LLP	Raleigh	NC
Wyatt Law Firm	San Antonio	TX
Young & Adams, Attorneys at Law	Boca Raton	FL
Young, Moore & Henderson, P.A.	Raleigh	NC
Zurich North America	Charlotte	NC

Partial List of Historical Insurance Firms

Client Name	*City*	*State*
Electric Insurance Company	Beverly	MA
Federated Rural Electric Insurance Corporation	Lenexa	KS
Federated Rural Insurance Corporation	Lenexa	KY
Nationwide Insurance	Durham	NC
St. Paul Fire and Marine Insurance Company	Charlotte	NC
VML Insurance Programs	Richmond	VA
Zurich American Insurance Company	Charlotte	NC

SEMINARS, PRESENTATIONS & PUBLICATIONS

October 11, 2017

Seminars/Presentations and Publications

North Carolina Association of Municipal Electrical Systems (NCAMES)

Date	*Location*	*Presentation/Seminar/Class Title*
1987	Annual Meeting	System Losses Overview
1990	Annual Meeting	NESC – Clearance & Liabilities
1992	Annual Meeting	CL Fuses Presentation
1993	Annual Meeting	NESC Revisions/Partial Review
1996	Annual Meeting May 13, 1996 Greensboro, NC	NESC 1997 Proposals/Partial Review
1997	Annual Meeting Charlotte, NC	Overhead High Voltage Line Safety Act
May 16-18, 2000	39th Annual Conference Raleigh, NC	Protective Relaying Principles Presentation
May 2000	Annual Meeting	Distribution System Protective Coordination Principles
May 2006	Annual Meeting	Asset Management Strategic Planning and Long-Range Planning
May 2007	Annual E & O Conference	Arc Flash Hazard and the NESC (Protection Assessment) Summary Presentation
April 2008	Annual E & O Conference Concord, NC	Long-Range Planning and Distribution Protection
May 2009	Annual Meeting	Economic System Improvements

National Rural Electric Cooperative Association (NRECA)

Date	*Location*	*Presentation/Seminar/Class Title*
July 18-20, 1983	St. Louis, MI	Store, Deter, Delay or Interrupt
Nov. 16, 1989		Report on Distribution Improvements that pay off through Lower Power Loss
1991	Annual Meeting	Distribution System Loss Management
1992		Distribution Loss Seminar
June 24-26, 1992	San Antonio, TX	Distribution System Loss Workshop
Sept. 23-24, 1993	Herndon, VA	Cost Effective Management of System Planning & Purchasing
January 2000		Recloser Actuator Engineering Analysis Update
February 2001	TechAdvantage Meeting	ABCs of System Planning
February 2002	TechAdvantage Meeting	Economic Conductor Sizing
August 2006	CRN Member Summit - Cooperative Research Council Meeting	Asset Management Strategic Planning Reliability and Trends

American Public Power Association (APPA)

Date	*Location*	*Presentation/Seminar/Class Title*
October 6-7, 1986	Kansas City, MI	Distribution Line Loss Seminar & Manual
Sept. 28-30, 1987	Raleigh, NC	Distribution Line Loss Seminar & Manual
April 11-13, 1988	Colorado Springs, CO	Distribution Line Loss Seminar & Manual
June 24, 1988		National Distribution Improvements Pay Off through Power Losses
October 12-14, 1988	Minneapolis, MN	Distribution Line Loss Guide

North Carolina Electric Membership Corporation & North Carolina Association of Electric Cooperatives (NCEMC & NCAEC)

Date	*Location*	*Presentation/Seminar/Class Title*
October 1986		NCAEC – Distribution System Loss Evaluation
October 30, 1986	Greenville Utilities Commissions	NCAEC – Reduce Losses in Distribution Systems
November 13, 1986	Crescent UMC Statesville, NC	NCAEC – Reduce Losses in Distribution Systems
1993	Operations Conference	1993 NESC Revisions Partial Review
December 12, 1996	Nash Community College, Rocky Mount, NC	NCAEC – Advanced Lineman Training NESC Introduction
June 1999	E & O Conference	Distribution Protective Coordination Workshop
June 2000	E & O Conference	NCAEC – Proposed changes to 1997 NESC
June 2001	E & O Conference	NCAEC – The NESC
December 5-6, 2001	System Engineer's Workshop	NCAEC -- The NESC
June 2002	E & O Conference	NCAEC – Overview of 2002 NESC Changes
September 2002	NCEMC Manager’s Conference, Sunset Beach, NC	NCEMC – Overview 2002 NESC Changes

Date	*Location*	*Presentation/Seminar/Class Title*
June 2007	2007 E & O Conference	NCAEC - Arc Flash Hazard and the NESC (Protection Assessment) Summary Presentation
December 6, 2007	System Engineers Workshop	NCAEC - Arc Flash Hazard and the NESC (Protection Assessment) 7 Hour Seminar and Manual
June 2008	2008 E & O Conference	NCAEC - Two Presentations: Arc Flash Hazard Update and The National Electrical Code and How it Applies to Utilities
August 2008	2008 Safety Coordinator's Workshop	NCEMC - Arc Flash Hazard Update
December 2008	2008 System Engineers' Workshop	NCAEC - Arc Flash Hazard Assessment Findings
December 2010	2010 System Engineers' Workshop	NCAEC – Power Quality
December 2011	2011 System Engineers' Workshop	NCAEC - National Electrical Safety Code Update
June 2013	2013 E&O Conference	Stray Voltage and Contact Voltage
December 2014	2014 System Engineers' Workshop	NCAEC-Pole Attachment – Joint Use
March 14-15, 2017	Rocky Mount, NC	Incident Investigation Training for Utility Professionals

North Carolina Electric Municipal Power Association (NCEMPA)
& ElectriCities of North Carolina, Inc.

Date	*Location*	*Presentation/Seminar/Class Title*
1983	Wake Tech. College Raleigh, NC	Distribution System Protective Coordination School and Manual
1985	Wake Tech. College Raleigh, NC	Distribution System Protection School
June 17, 1987	ElectriCities	NESC & Municipal Electric System Safety Seminar
Sept. 28-30, 1988	Raleigh, NC	Distribution System Loss Evaluation Manual
November 1990	ElectriCities	NESC Course Manual
Dec. 11-12, 1991	ElectriCities	NESC
November 1992	ElectriCities	NESC Course Manual
Nov. 17-18, 1993	Raleigh, NC	NESC School
Nov. 16-17, 1994	ElectriCities	NESC Seminar
November 13, 1996	ElectriCities	1997 NESC Course
December 11, 2007	City of Wilson, North Carolina	Arc Flash Hazard and the NESC (Protection Assessment) 4 Hour Workshop for Municipalities
December 2007	City of Lexington, NC	Arc Flash Hazard Assessment and the NESC 8 hour Workshop and Manual

Other

Date	*Location*	*Presentation/Seminar/Class Title*
May 1988	SC Public Service Authority-Santee Cooper	NESC Training Guide
November 14, 1989	City of Bennettsville, SC	Value of System Planning
1990	Joe Wheeler EMC Hartselle, AL	NESC
May 1990	Northeast Assoc. of Electric Cooperatives	Power Quality Presentation & Distribution Cost Trends Presentation
May 22-24, 1990	New England Statewide	NARC
Dec. 10-11, 1990	Lexington, NC	NESC School
Dec. 26, 1990	City of Kinston, NC	NESC Course
1993	Davidson Electric Membership Cooperative Lexington, NC	NESC Course Manual Partial Review
Jan. 12-14, 1993	Rappahannock Electric Cooperative Fredericksburg, VA	Distribution System Loss Management Workshop
June 18-19, 1993	Joe Wheeler EMC Hartselle, AL	NESC School
July 2000	CP&L Raleigh, NC	CP&L Accident Investigation Workshop

Date	***Location***	***Presentation/Seminar/Class Title***
June 2000	SCAMPS Annual Meeting	Distribution System Protective Coordination Principles
June 2001	SCAMPS Annual Meeting	Accident Investigation and Avoidance Issues
February 2002	SCAMPS Columbia, SC	2002 NESC Workshop and Manual
July 2002	Florida Municipal Electric Association Orlando, FL	2002 NESC and Manual
April 2003	Old Dominion Electric Cooperative	Load Research Relevance to Distribution Planning
April 2004	Virginia, Maryland & Delaware Association of Electric Cooperatives	• System Grounding Presentation • Capacitor Placement & Power Factor Correction • System Planning
May 2004	Virginia, Maryland & Delaware Association of Electric Cooperatives	Interval Data and Construction Work Plan Design
January 2008	PREA State College, PA	Arc Flash Hazard and the NESC (Protection Assessment) Summary Presentation
April 15, 2008	Virginia, Maryland & Delaware Association of Electric Cooperatives	Arc Flash Hazard and the NESC (Protection Assessment) 7 Hour Workshop and Manuals
July 13, 2009	SCAMPS Annual Meeting	Maximizing Utility Resources Through Best Practices
April 29, 2010	PREA CEO Meeting, State College, PA	NERC Compliance Monitoring & Enforcement Presentation (Summary)
June 24, 2010	PREA 2010 Workshop, State College, PA	NERC Compliance Monitoring & Enforcement Presentation (Detailed)

Date	*Location*	*Presentation/Seminar/Class Title*
May 5, 2011	Virginia, Maryland & Delaware Association of Electric Cooperatives	Pole Attachment Review
August 29, 2012	LeClair Ryan Webinar	Energy Audits
November 20, 2012	Schultz Law Webinar	Subrogation of Workers' Comp. Claims Involving Electrical Contact Injuries
December 7, 2012	PWC of the City of Fayetteville, NC	Why Follow Engineering Design and the NESC Linemen Presentation
August 20, 2013	RESMA Lobbying Clinic, Virginia	Pole Attachment Dispute Discussion
January 19, 2015	PWC of the City of Fayetteville, NC	Arc Flash Risk Assessment – Industrial and Commercial Facilities
April 30, 2015	Northwestern Rural Electric Cooperative Association	Joint Use Pole Attachment – PA & Regional Issues
May 6-7, 2015	Virginia, Maryland & Delaware Association of Electric Cooperatives	Joint Use Pole Attachment – VA & Regional Issues
November 30, 2016	Rappahannock Electric Cooperative, VA	2017 NESC Update

Distribution System Loss Evaluation Seminars

Date	*Location*
September 30 – October 2, 1991	Marco Island, FL
November 15, 1991	Albuquerque, NM
November 18, 1991	St. Louis, MI
November 22, 1991	Charlotte, NC
January 15, 1992	Jones Onslow EMC Jacksonville, NC
May 11-13, 1992	Nashville, TN
September 30 – October 2, 1992	Northwest Public Power Association Seattle, WA
October 4-7, 1992	District Manager's Conference San Antonio, TX
November 12, 1992	Four County EMC Burgaw, NC
July 18-21, 1993	Materials Management Conference Hilton Head, SC
October 13-16, 1993	Northwest Public Power Authority Portland, OR
June 15-17, 1994	North Carolina Association of Electric Cooperatives E&O Conference Sunset Beach, NC
October 18, 1994	North Carolina Electric Membership Cooperative Raleigh, NC

Date	***Location***
October 23-26, 1994	NRECA E&O Conference Jacksonville, FL
January 17, 1995	United EC Dubois, PA
November 20 – December 1, 1995	Minneapolis, MN
December 14-15, 1995	Nashville, TN
May 22-24, 1996	San Antonio, TX
June 12-14, 1996	Denver, CO
April 22-23, 1997	Minneapolis, MN
	North Carolina Alternative Energy Corporation Distribution System Loss Reduction Manual and Courses
May 9, 2000	Lewis County REC Lewistown, MI

National and State Publications

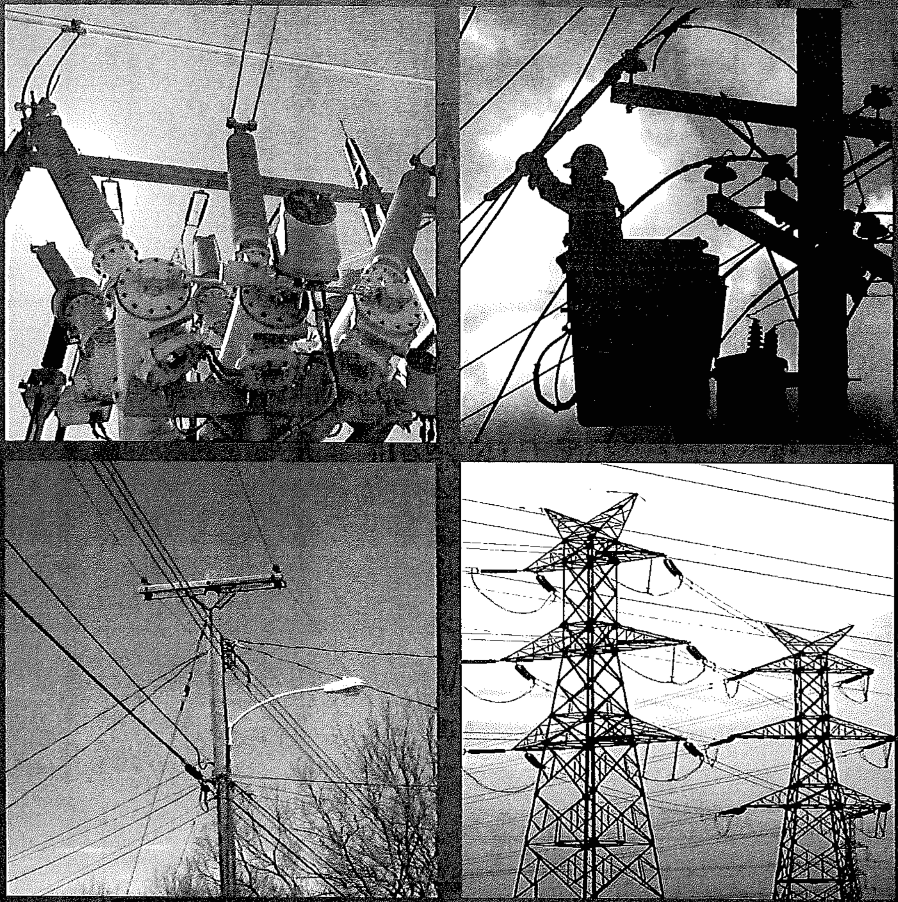
Date	***Publications***
1983	North Carolina Alternative Energy Corporation Distribution System Loss Reduction Manual and Courses
1983	Distribution System Protective Coordination Manual ElectriCities of North Carolina
1986	Distribution System Loss Evaluation Manual American Public Power Association
1991	Distribution System Loss Management Manual – NRECA (2 manuals, 6 National Workshops and Manuals)
1994	Distribution System Loss Reduction Manual Tennessee Valley Public Power Association, Research & Development
1998	Distribution Protective Coordination Workshop and Manual ElectriCities of North Carolina
June 1999	Distribution Protective Coordination Workshop and Manual
2000	Improving Distribution System Performance
2001	National Electrical Safety Code Workshop Materials
2001	Evaluation of Recloser Actuators – NRECA
2003	Power Loss Management Manual for the Deregulated Utility Environment NRECA-CRN
2004	Power Loss Management Manual for the Deregulated Utility Environment NRECA-CRN Computer Based Training CD and Power Loss Management Interactive CD Publication

Date	***Publications***
2004	Virginia, Maryland & Delaware Association of Electric Cooperatives • System Grounding Materials • Capacitor Placement & Power Factor Correction Materials • System Planning Materials
2004	Interval Data and Construction Work Plan Design Materials
2007	Arc Flash Hazard and the NESC (Protection Assessment) Seminar Materials

EXHIBIT GLB-2

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.

Approved 26 April 2016
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

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

ISBN 978-1-5044-1993-2

1 August 2016 STDPT20924

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.

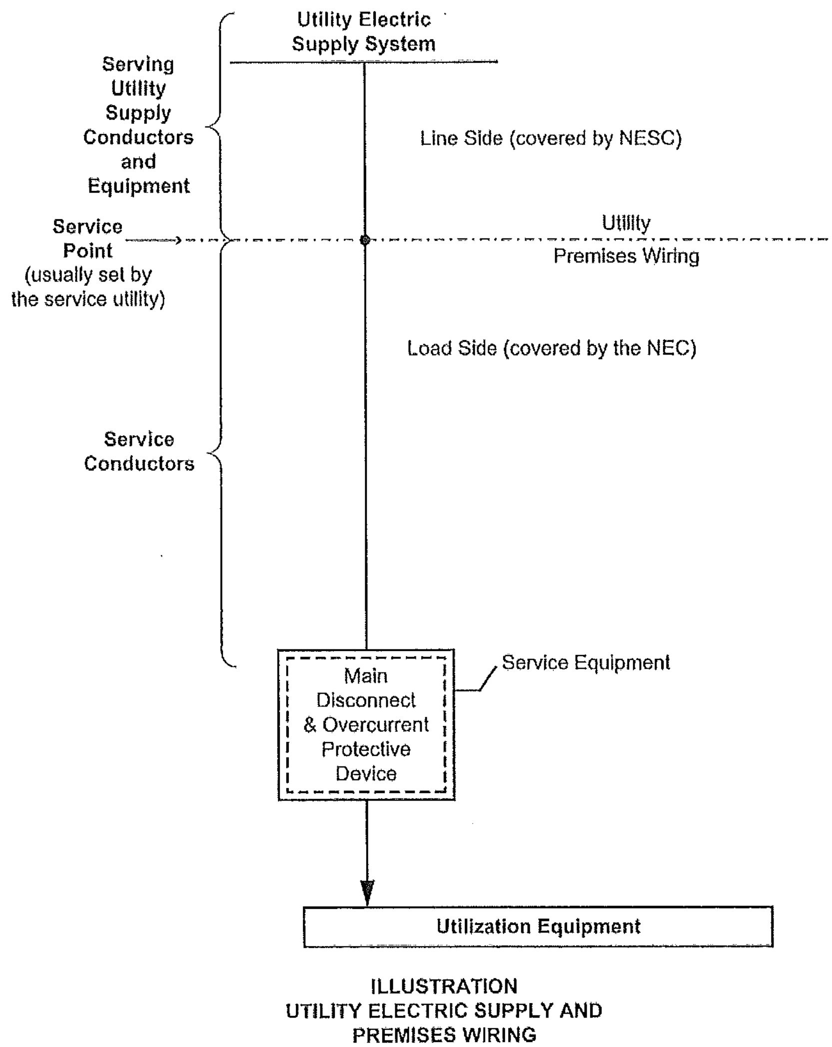


Figure 011-1—Service point—General illustration of what is covered and not covered by the NESC

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.

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.

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 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)
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. ㉖	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.

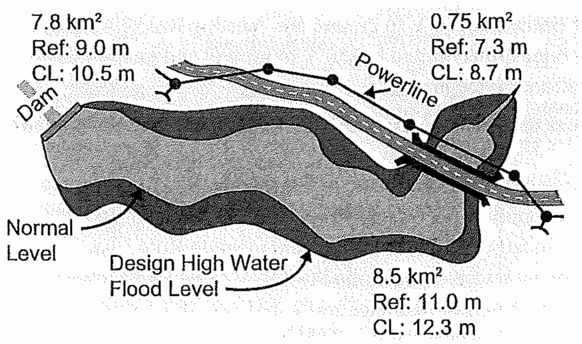
⑲The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1.6 km long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for 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 [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)
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	—	—

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.

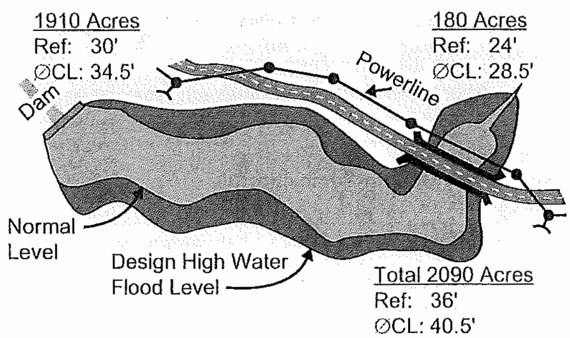
⑲The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1 mi long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for 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.

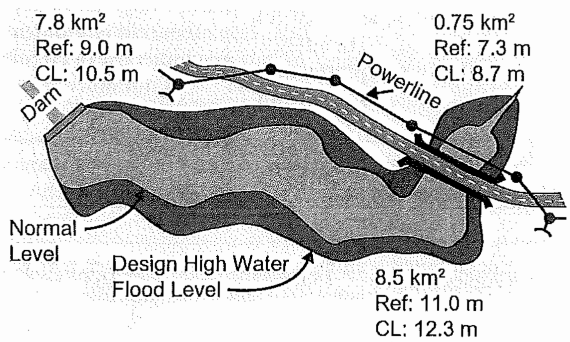
⑪The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1.6 km long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for 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 ⑧⑨⑩⑪⑫			
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.

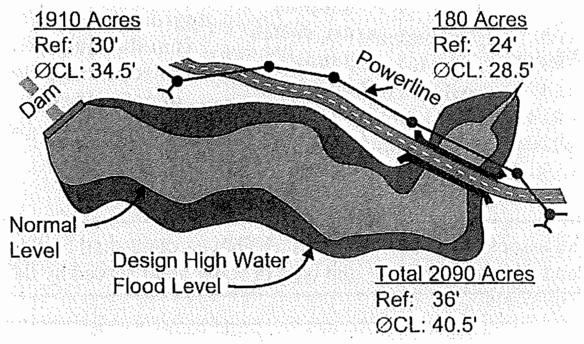
⑪The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1 mi long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for 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.

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.

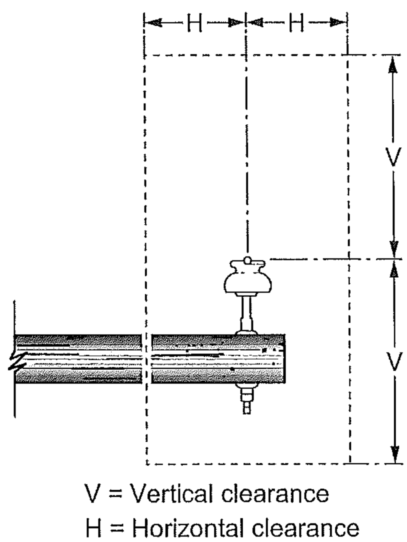


Figure 235-1—Clearance diagram for energized conductor

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 levels⑫	Conductors and cables usually at upper levels ⑫			
	Supply cables meeting Rule 230C1, 230C2, or 230C3; neutral conductors meeting Rule 230E1; communica-tions cables meeting Rule 224A2 (m)	Open supply conductors		
		0 to 8.7 kV⑪ (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.

OFFICIAL COPY

Oct 16 2017

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)	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 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)	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 ③ ⑥ in excess of 8.7 kV	16 plus 0.4 per kV ③ ⑥ in excess of 8.7 kV
d. Open conductors exceeding 22 kV, but not exceeding 50 kV			16 plus 0.4 per kV ③ ⑥ in excess of 8.7 kV	40 plus 0.4 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 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 kV ⑧ 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	125 ③ 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)	Supply lines: Circuit phase-to-phase voltage: 0 to 8.7 kV [14] (in)	Supply lines: Circuit phase-to-phase voltage: Over 8.7 kV to 50 kV (in)	Supply lines: Circuit phase-to-phase voltage: 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	30 ⑯	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	1.24②	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	4.1②	161 ②	3.8	148
	2.0	1306	4.1②	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).

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.

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.

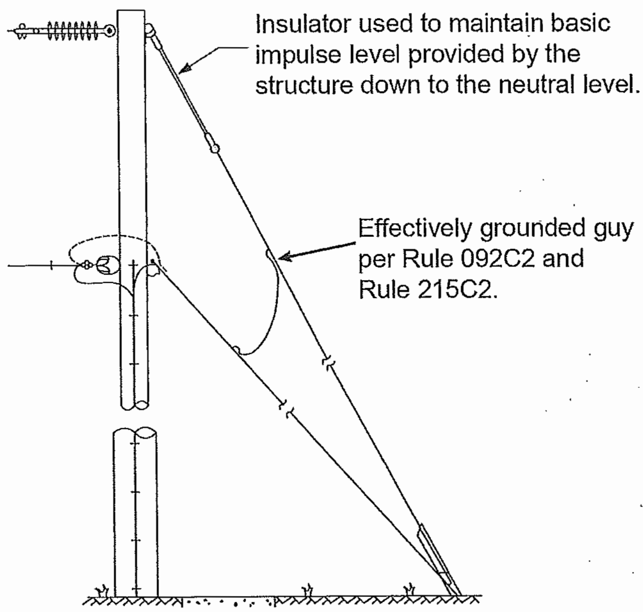


Figure 279-1—Insulator used for BIL insulation

28. Section number 28 not used in this edition.

29. Section number 29 not used in this edition.

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.

$$\text{Load in newtons} = 0.613 \cdot (V_{m/s})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f \cdot A(m^2)$$

$$\text{Load in pounds} = 0.00256 \cdot (V_{mi/h})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f \cdot A(ft^2)$$

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.

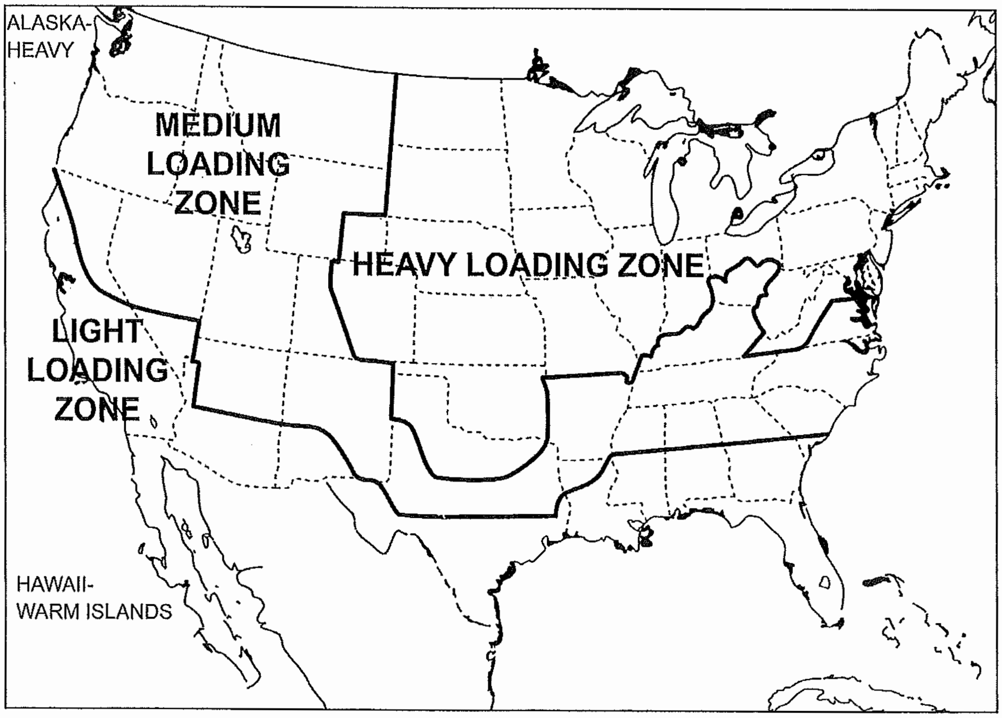
NOTE: Where structure heights are 50 m (165 ft) or less and spans are 600 m (2000 ft) or less, the combined product of k_z and G_{RF} may be conservatively taken as 1.15 if it is desired to simplify calculations.

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

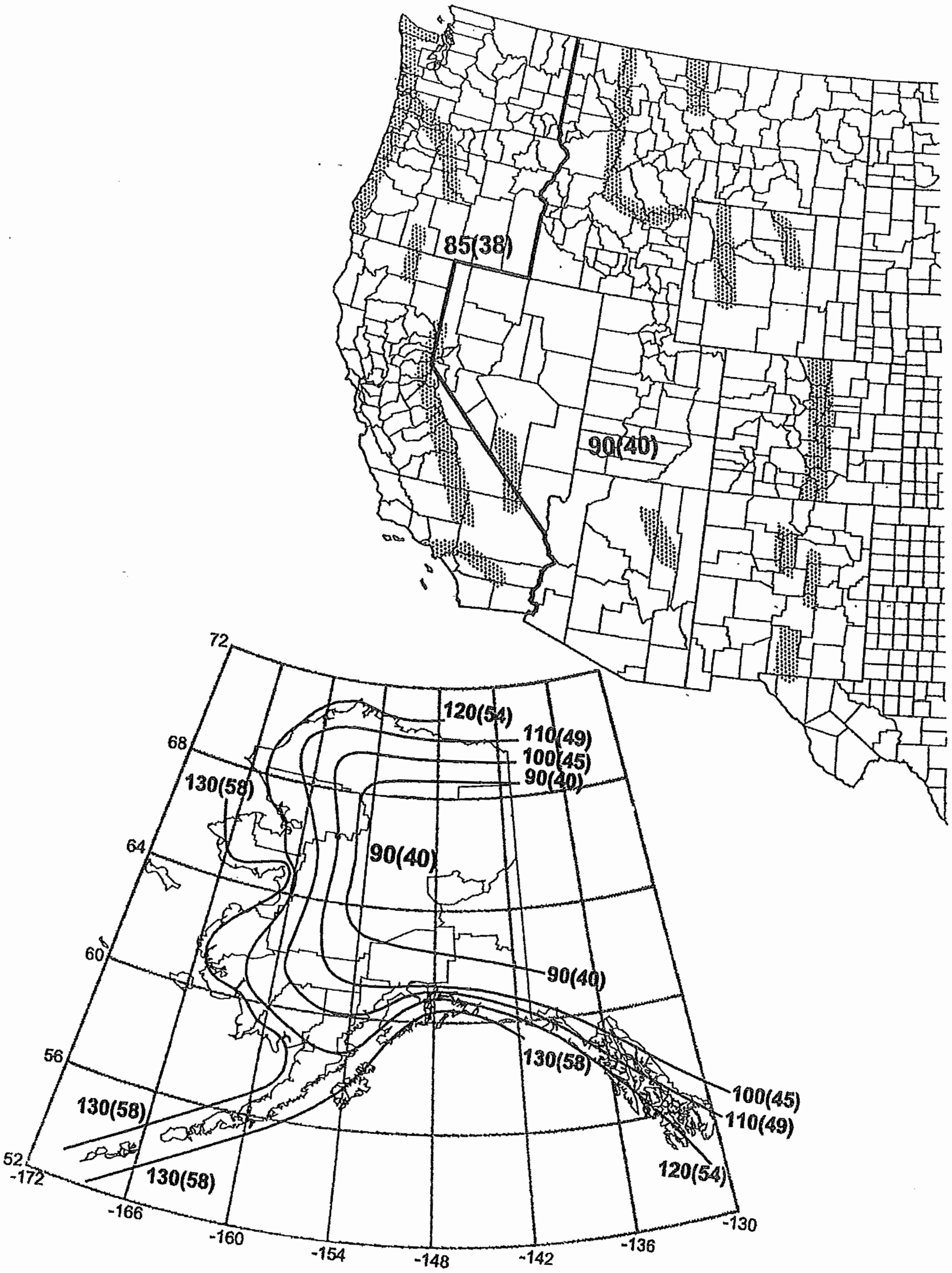
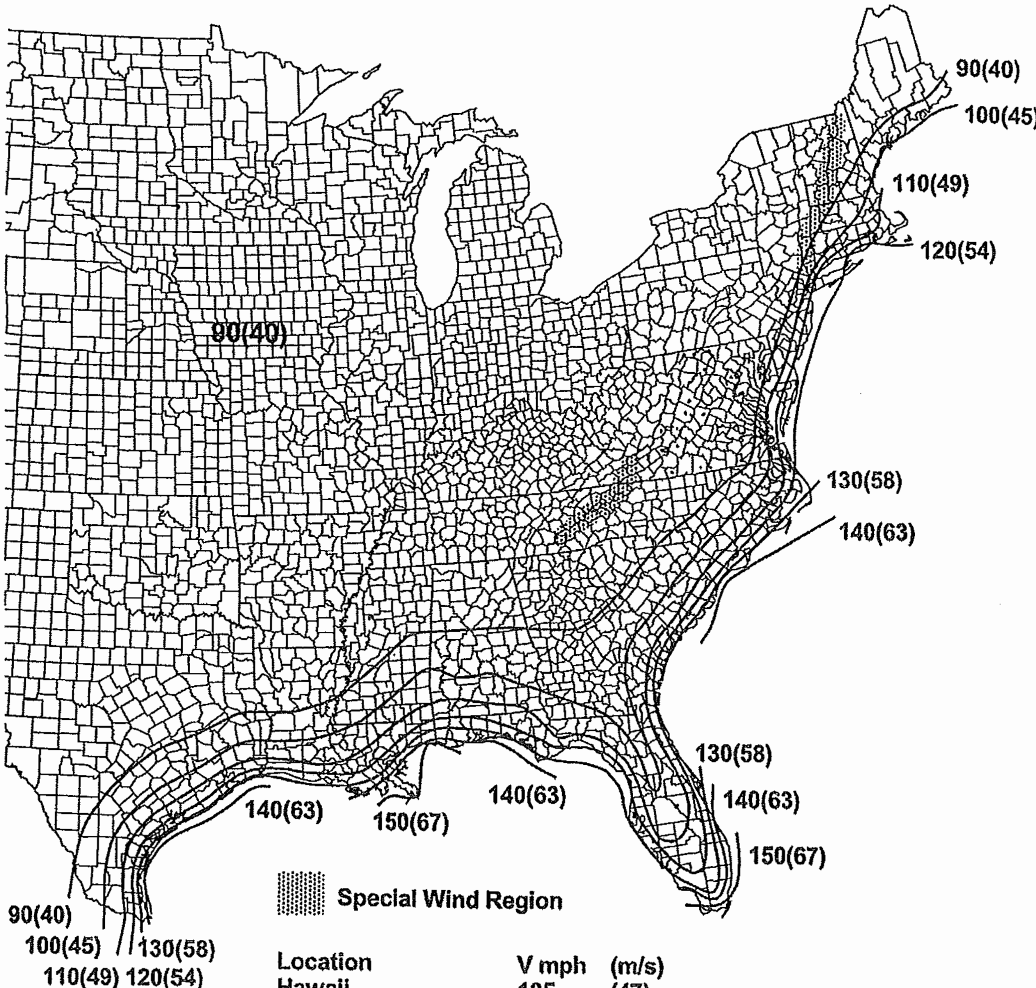


Figure 250-2(a)—Basic wind speeds

NOTE: Figure 250-2(a) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191 from ASCE 74-10, Guidelines for Electrical Transmission Line Structural Loading. Copyright © 2010.



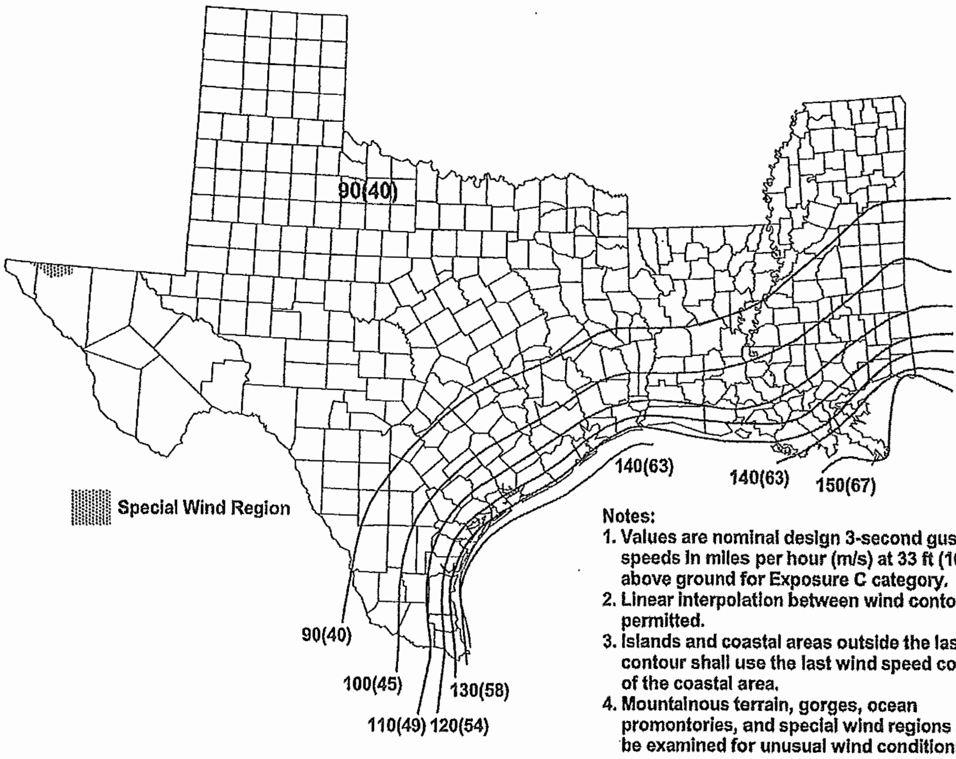
Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

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

NOTE: Figure 250-2(b) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191 from ASCE 74-10, Guidelines for Electrical Transmission Line Structural Loading. Copyright © 2010.



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(c)—Western Gulf of Mexico hurricane coastline

NOTE: Figure 250-2(c) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191 from ASCE 74-10, Guidelines for Electrical Transmission Line Structural Loading. Copyright © 2010.

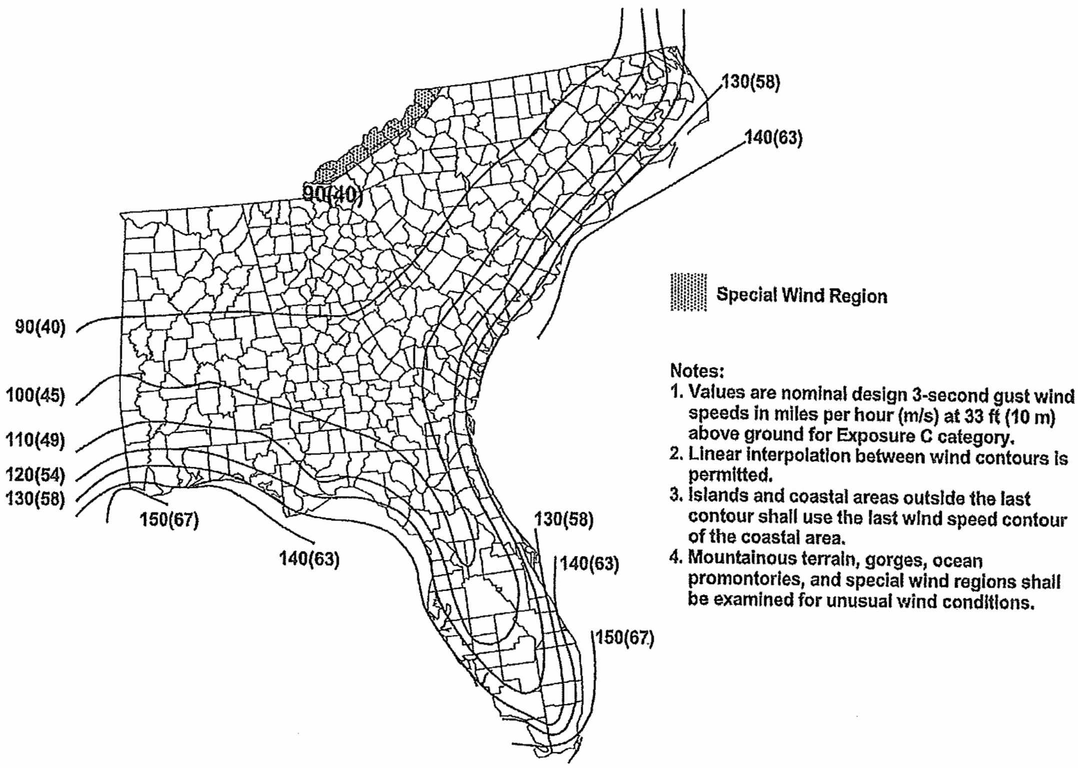


Figure 250-2(d)—Eastern Gulf of Mexico and southeastern U.S. hurricane coastline

NOTE: Figure 250-2(d) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191 from ASCE 74-10, Guidelines for Electrical Transmission Line Structural Loading. Copyright © 2010.

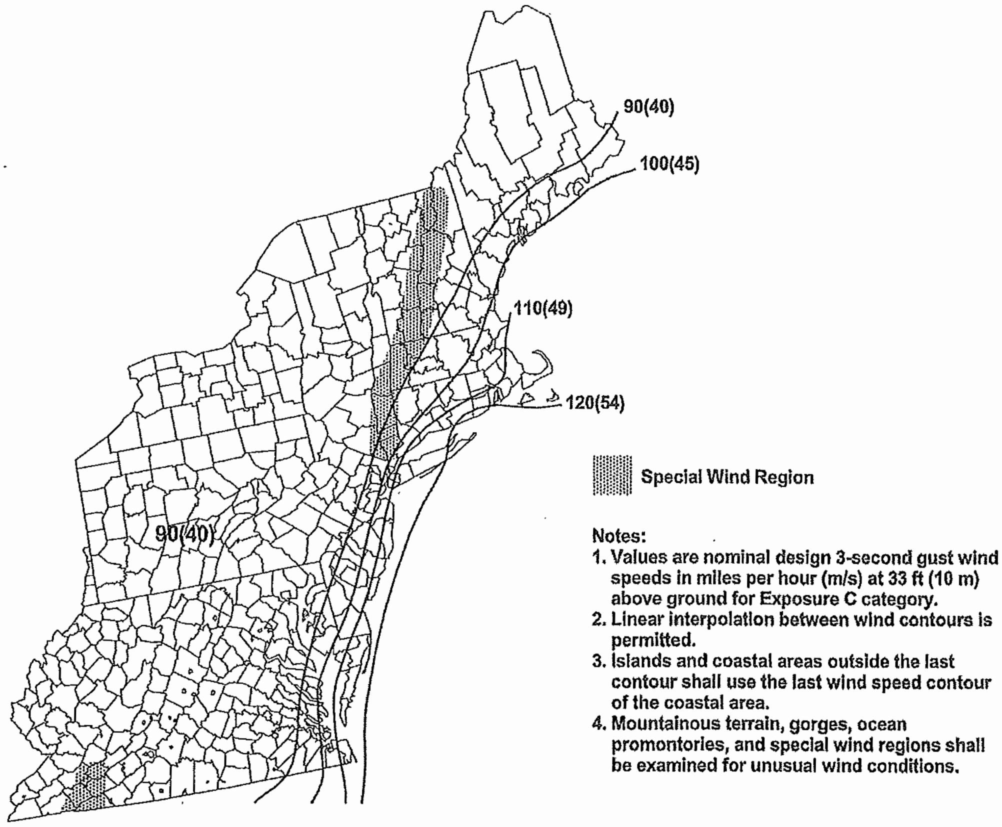
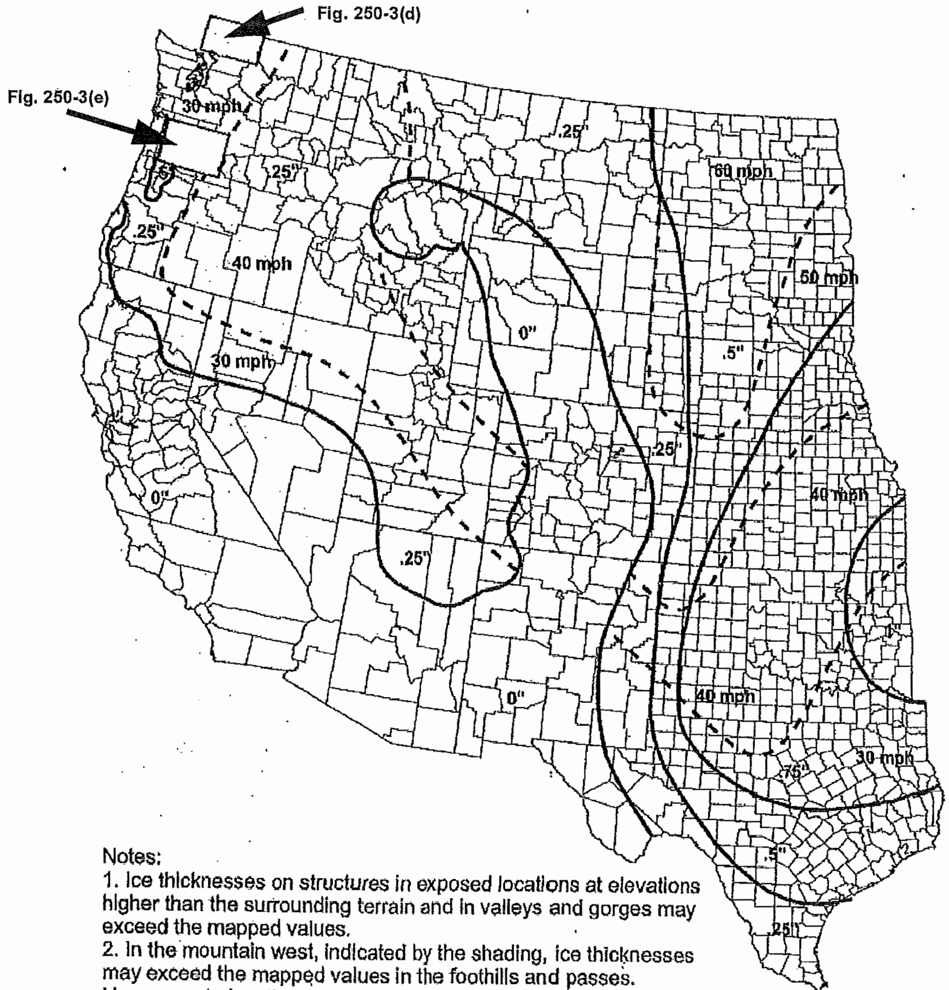


Figure 250-2(e)—Mid and northern Atlantic hurricane coastline

NOTE: Figure 250-2(e) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191 from ASCE 74-10, Guidelines for Electrical Transmission Line Structural Loading. Copyright © 2010.

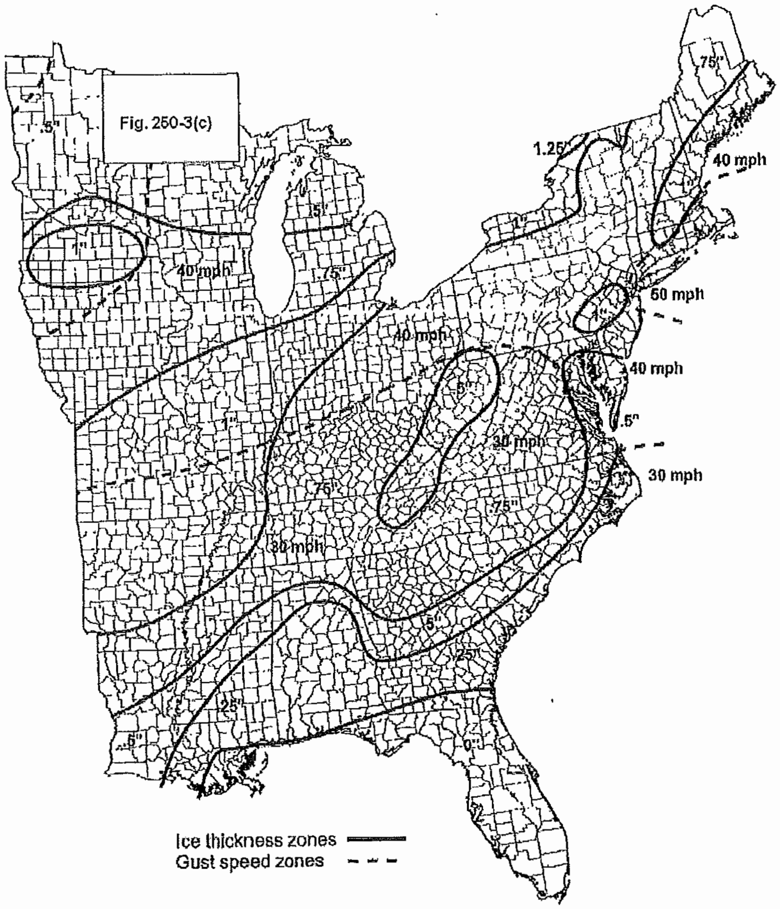


Notes:
1. Ice thicknesses on structures in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values.
2. In the mountain west, indicated by the shading, ice thicknesses may exceed the mapped values in the foothills and passes. However, at elevations above 5,000 ft, freezing rain is unlikely.
3. In the Appalachian Mountains, indicated by the shading, ice thicknesses may vary significantly over short distances.

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

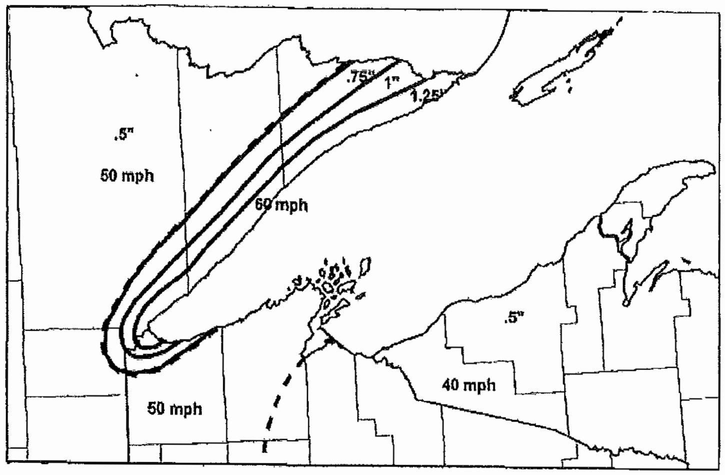
NOTE: Figure 250-3(a) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191, from ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Copyright © 2010.



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

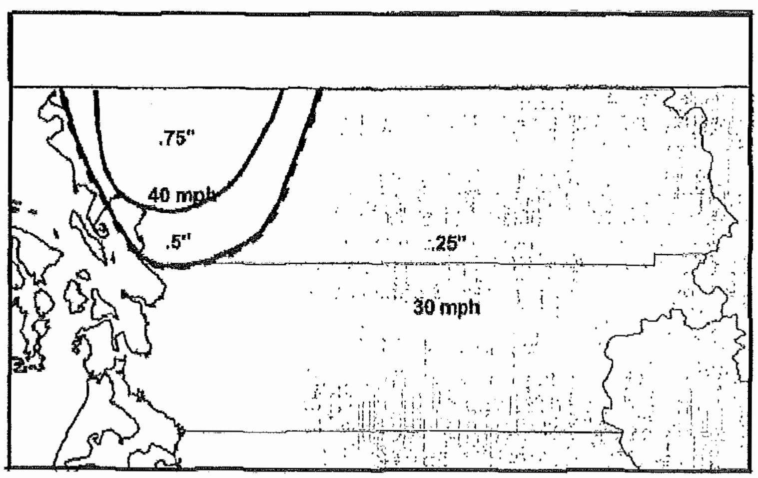
NOTE: Figure 250-3(b) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191, from ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Copyright © 2010.



LAKE SUPERIOR DETAIL

Figure 250-3(c)—Uniform ice thickness with concurrent wind

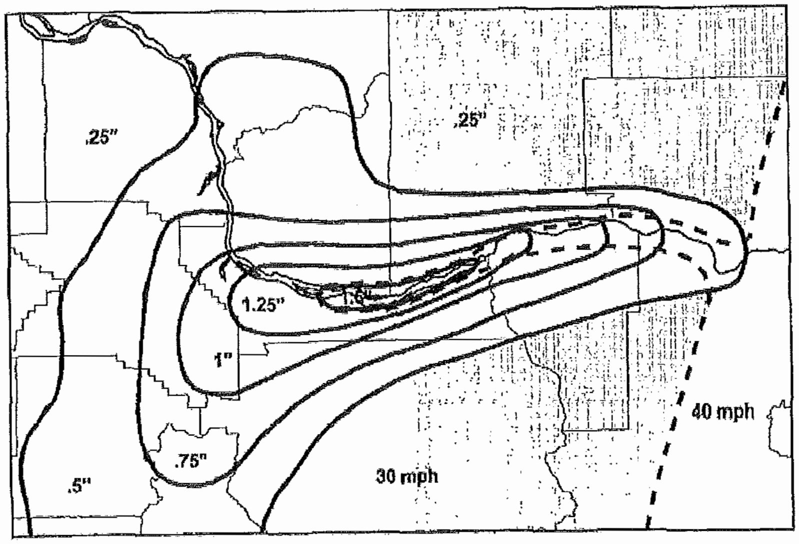
NOTE: Figure 250-3(c) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191, from ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Copyright © 2010.



FRASER VALLEY, WASHINGTON DETAIL

Figure 250-3(d)—Uniform ice thickness with concurrent wind

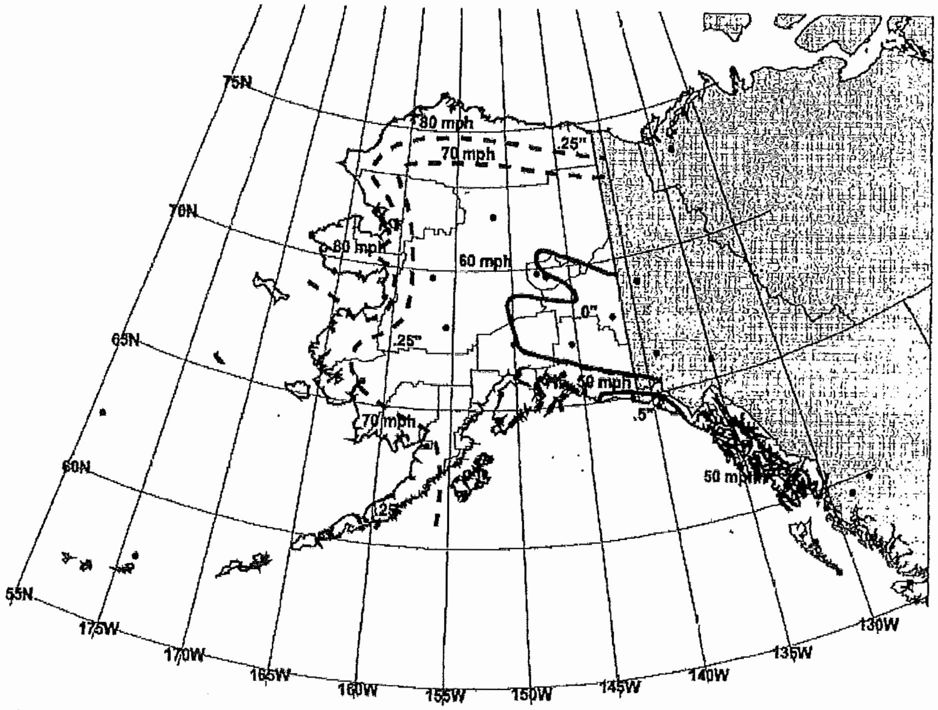
NOTE: Figure 250-3(d) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191, from ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Copyright © 2010.



COLUMBIA RIVER GORGE, WASHINGTON DETAIL

Figure 250-3(e)—Uniform ice thickness with concurrent wind

NOTE: Figure 250-3(e) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191, from ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Copyright © 2010.



Ice thickness zones
Gust speed zones
Weather stations

Note:
Ice thicknesses in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values

50-YEAR MEAN RECURRENCE INTERVAL UNIFORM ICE THICKNESSES DUE TO FREEZING RAIN WITH CONCURRENT 3-SECOND GUST SPEEDS: ALASKA

Figure 250-3(f)—Uniform ice thickness with concurrent wind

NOTE: Figure 250-3(f) reprinted with permission from ASCE, 1801 Alexander Bell Dr., Reston, VA 20191, from ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Copyright © 2010.

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	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)		
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

①Warm 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	$k_z = 2.01 \cdot (0.67 \cdot h/275)^{(2/9.5)}$ $k_z = 1.85$	$h \le 275$ m $h > 275$ m
Wire, specified height on the structure, and component	$k_z = 2.01 \cdot (h/275)^{(2/9.5)}$ $k_z = 2.01$	$h \le 275$ m $h > 275$ m

Formulas (customary):

Structure	$k_z = 2.01 \cdot (0.67 \cdot h/900)^{(2/9.5)}$ $k_z = 1.85$	$h \le 900$ ft $h > 900$ ft
Wire, specified height on the structure, and component	$k_z = 2.01 \cdot (h/900)^{(2/9.5)}$ $k_z = 2.01$	$h \le 900$ ft $h > 900$ 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.

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.

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.

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 structures①, 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

①Includes pole.
②For guys and anchors associated with structures supporting communication conductors and cables only, this factor may be reduced to 1.33.
③Where 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.
④For metal or prestressed concrete, portions of structures, crossarms, guys, foundations, and anchors, use a value of 1.10.
⑤For metal, prestressed concrete, or fiber-reinforced polymer portions of structures and crossarms, guys, foundations, and anchors, use a value of 1.50.
⑥This applies only where a line crosses another supply or communication line (see Rule 241C and Table 242-1).
⑦For wind velocities above 100 mph (except Alaska), a factor of 0.75 may be used.
⑧Support 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.