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NFPA 70 (2014), the National Electrical Code, as adopted and required by the Commonwealth of Massachusetts in 527 CMR 12.00 and by the City of Montgomery, Alabama per Ordinance No. 64-2013, amending Section 5-111 of the Code of Ordinances.

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IPR2024-00876

NFPA 70®

2014

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National Electrical Code®
International Electrical Code® Series

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ISBN: 978-145590672-7 (SB Print)
ISBN: 978-145590671-0 (LL Print)
ISBN: 978-145590673-4 (Spiral Print)
ISBN: 978-145590680-2 (PDF)

NFPA 70®

National Electrical Code®

2014 Edition

This edition of *NFPA 70, National Electrical Code*, was prepared by the National Electrical Code Committee and acted on by NFPA at its June Association Technical Meeting held June 10–13, 2013, in Chicago, IL. It was issued by the Standards Council on August 1, 2013, with an effective date of August 21, 2013, and supersedes all previous editions.

A tentative interim amendment (TIA) to Sections 516.3 and 516.10 was issued on August 1, 2013. For further information on tentative interim amendments, see Section 5 of the NFPA Regulations Governing Committee Projects available at: <http://www.nfpa.org/assets/files/PDF/CodesStandards/TIAErrataFI/TIAREgs.pdf>.

This edition of NFPA 70 was approved as an American National Standard on August 21, 2013.

History and Development of the *National Electrical Code*®

The National Fire Protection Association has acted as sponsor of the *National Electrical Code* since 1911. The original *Code* document was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests.

In accordance with the provisions of the NFPA Regulations Governing Committee Projects, a National Electrical Code Committee Report on Proposals containing proposed amendments to the 2008 *National Electrical Code* was published by NFPA in July 2009. This report recorded the actions of the various Code-Making Panels and the Correlating Committee of the National Electrical Code Committee on each proposal that had been made to revise the 2008 *Code*. The report was circulated to all members of the National Electrical Code Committee and was made available to other interested NFPA members and to the public for review and comment. Following the close of the public comment period, the Code-Making Panels met, acted on each comment, and reported their action to the Correlating Committee. NFPA published the National Electrical Code Committee Report on Comments in March 2010, which recorded the actions of the Code-Making Panels and the Correlating Committee on each public comment to the National Electrical Code Committee Report on Proposals. The National Electrical Code Committee Report on Proposals and the National Electrical Code Committee Report on Comments were presented to the 2010 June Association Technical Meeting for adoption.

NFPA has an Electrical Section that provides particular opportunity for NFPA members interested in electrical safety to become better informed and to contribute to the development of the *National Electrical Code* and other NFPA electrical standards. At the Electrical Section Codes and Standards Review Session held at the 2010 NFPA Conference and Expo, Section members had opportunity to discuss and review the report of the National Electrical Code Committee prior to the adoption of this edition of the *Code* by the Association at its 2010 June Technical Session.

This 53rd edition supersedes all other previous editions, supplements, and printings dated 1897, 1899, 1901, 1903, 1904, 1905, 1907, 1909, 1911, 1913, 1915, 1918, 1920, 1923, 1925, 1926, 1928, 1930, 1931, 1933, 1935, 1937, 1940, 1942, 1943, 1947, 1949, 1951, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1962, 1965, 1968, 1971, 1975, 1978, 1981, 1984, 1987, 1990, 1993, 1996, 1999, 2002, 2005, 2008, and 2011.

This *Code* is purely advisory as far as NFPA is concerned. It is made available for a wide variety of both public and private uses in the interest of life and property protection. These include both use in law and for regulatory purposes, and use in private self-regulation and standardization activities such as insurance underwriting, building and facilities construction and management, and product testing and certification.

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NATIONAL ELECTRICAL CODE COMMITTEE

These lists represent the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this document.

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Committee Scope: This Committee shall have primary responsibility for documents on minimizing the risk of electricity as a source of electric shock and as a potential ignition source of fires and explosions. It shall also be responsible for text to minimize the propagation of fire and explosions due to electrical installations.

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Fernando E. Pacheco, Methanex Chile SA, TX [U]
(Alt. to Charles L. Boynton)
Rep. American Chemistry Council
Stephen J. Thorwegen, Jr., FSG Electric, TX [IM]
(Alt. to Robert G. Wilkinson)
Rep. Independent Electrical Contractors, Inc.
Charles M. Trout, Maron Electric Company, FL [IM]
(Alt. to Thomas H. Wood)
Rep. National Electrical Contractors Association

Nonvoting

William Burr, Canadian Standards Association, Canada [RT]
Douglas A. Lee, U.S. Consumer Product Safety Commission, MD [C]
Andrew M. Trotta, U.S. Consumer Product Safety Commission, MD [C]
(Alt. to Douglas A. Lee)

CODE-MAKING PANEL NO. 3

Articles 300, 590, 720, 725, 727, 728, 760, Chapter 9, Tables 11(A) and (B), and Tables 12(A) and (B)

Paul J. Casparro, *Chair*
Scranton Electricians JATC, PA [L]
Rep. International Brotherhood of Electrical Workers

Steven D. Burlison, Progress Energy, FL [UT]
Rep. Electric Light & Power Group/EEI
Shane M. Clary, Bay Alarm Company, CA [M]
Rep. Automatic Fire Alarm Association, Inc.
Adam D. Corbin, Corbin Electrical Services, Inc., NJ [IM]
Rep. Independent Electrical Contractors, Inc.
Les Easter, Atkore International, IL [M]
Rep. National Electrical Manufacturers Association
Stanley D. Kahn, Tri-City Electric Company, Inc., CA [IM]
Rep. National Electrical Contractors Association
Ray R. Keden, ERICO, Inc., CA [M]
Rep. Building Industry Consulting Services International
Steven J. Owen, Steven J. Owen, Inc., AL [IM]
Rep. Associated Builders & Contractors
David A. Pace, Olin Corporation, AL [U]
Rep. American Chemistry Council
Mark A. Sepulveda, USA Alarm Systems, Inc., CA [IM]
Rep. Electronic Security Association
(VL to 720, 725, 727, 760)
John E. Sleights, Travelers Insurance Company, CT [I]
Susan L. Stene, UL LLC, CA [RT]
Robert J. Walsh, City of Hayward, CA [E]
Rep. International Association of Electrical Inspectors
Wendell R. Whistler, Intertek Testing Services, OR [RT]

Alternates

Richard S. Anderson, RTKL Associates Inc., VA [M]
(Alt. to Ray R. Keden)
Rep. Building Industry Consulting Services International

Sanford E. Egesdal, Egesdal Associates PLC, MN [M]
(Alt. to Shane M. Clary)
Rep. Automatic Fire Alarm Association, Inc.
Michael J. Farrell III, Lucas County Building Regulation, MI [L]
(Alt. to Paul J. Casparro)
Rep. International Brotherhood of Electrical Workers
Danny Liggett, The DuPont Company, Inc., TX [U]
(Alt. to David A. Pace)
Rep. American Chemistry Council
Mark C. Ode, UL LLC, AZ [RT]
(Alt. to Susan L. Stene)
Roger S. Passmore, IES Industrial, Inc., SC [IM]
(Alt. to Steven J. Owen)
Rep. Associated Builders & Contractors
Louis P. Petrucci, Jr., Bonner Electric Inc., RI [IM]
(Alt. to Adam D. Corbin)
Rep. Independent Electrical Contractors, Inc.
George A. Straniero, AFC Cable Systems, Inc., NJ [M]
(Alt. to Les Easter)
Rep. National Electrical Manufacturers Association
Joseph J. Wages, Jr., Springdale, AR [E]
(Alt. to Robert J. Walsh)
Rep. International Association of Electrical Inspectors

Nonvoting

Edward C. Lawry, Oregon, WI [E]
(Member Emeritus)

CODE-MAKING PANEL NO. 4

Articles 225, 230, 690, 692, 694, 705

Ronald J. Toomer, *Chair*
Toomer Electrical Company Inc., LA [IM]
Rep. National Electrical Contractors Association

Malcolm Allison, Mersen USA Newburyport-MA, LLC, NH [M]
Rep. National Electrical Manufacturers Association
Ward I. Bower, Solar Energy Industries Association, NM [U]
(VL to 690, 692, 705)
Thomas E. Buchal, Intertek Testing Services, NY [RT]
James G. Cialdea, Three-C Electrical Company Inc., MA [IM]
Rep. InterNational Electrical Testing Association
Ronald Todd Fries, HellermannTyton, WI [M]
Mark D. Gibbs, Babcock & Wilcox Y-12, LLC, TN [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
Roger D. McDaniel, Georgia Power Company, GA [UT]
Rep. Electric Light & Power Group/EEI

Alternates

Paul D. Barnhart, UL LLC, NC [RT]
(Alt. to Timothy P. Zgonena)

James J. Rogers, Towns of Oak Bluffs, Tisbury, West Tisbury, MA [E]
Rep. International Association of Electrical Inspectors
John A. Sigmund, PPG Industries, Inc., LA [U]
Rep. American Chemistry Council
Todd W. Stafford, National Joint Apprentice & Training Committee, TN [L]
Rep. International Brotherhood of Electrical Workers
Robert H. Wills, Intergrid, LLC, NH [U]
Rep. American Wind Energy Association
(VL to 690, 692, 694, 705)
Timothy P. Zgonena, UL LLC, IL [RT]
Vincent C. Zinnante, Westpoint Electric Inc., TX [IM]
Rep. Independent Electrical Contractors, Inc.

Alex Z. Bradley, The DuPont Company, Inc., DE [U]
(Alt. to John A. Sigmund)
Rep. American Chemistry Council

William F. Brooks, Brooks Engineering, CA [U]
 (Alt. to Ward I. Bower)
 Rep. Solar Energy Industries Association (VL to 690, 692, 705)
Larry D. Cogburn, Cogburn Bros., Inc., FL [IM]
 (Alt. to Ronald J. Toomer)
 Rep. National Electrical Contractors Association
Brian L. Crise, NIETC, OR [L]
 (Alt. to Todd W. Stafford)
 Rep. International Brotherhood of Electrical Workers
Barry N. Hornberger, PECO Energy Company, PA [UT]
 (Alt. to Roger D. McDaniel)
 Rep. Electric Light & Power Group/EEI
Tim LaLonde, Haskin Electric, Inc., WA [IM]
 (Alt. to Vincent C. Zinnante)
 Rep. Independent Electrical Contractors, Inc.
Howard Liu, Intertek Testing Services, NY [RT]
 (Alt. to Thomas E. Buchal)

Robert W. Preus, Advanced Renewable Technology, LLC, OR [U]
 (Alt. to Robert H. Wills)
 Rep. American Wind Energy Association (VL to 690, 692, 694, 705)
Patrick G. Salas, General Electric Company, CT [M]
 (Alt. to Malcolm Allison)
 Rep. National Electrical Manufacturers Association
Glenn A. Soles, Clark County Department of Development Services, NV [E]
 (Alt. to James J. Rogers)
 Rep. International Association of Electrical Inspectors

Nonvoting

Stephen W. Douglas, QPS Evaluation Services Inc., Canada [SE]
 Rep. CSA/Canadian Electrical Code Committee

CODE-MAKING PANEL NO. 5

Articles 200, 250, 280, 285

Nathan Philips, *Chair*
 Integrated Electronic Systems, OR [IM]
 Rep. National Electrical Contractors Association

Trevor N. Bowmer, Telcordia Technologies, NJ [U]
 Rep. Alliance for Telecommunications Industry Solutions
David Brender, Copper Development Association, Inc., NY [M]
 Rep. Copper Development Association Inc.
Martin J. Brett, Jr., Wheatland Tube Company, DE [M]
 Rep. American Iron and Steel Institute
Paul Dobrowsky, Innovative Technology Services, NY [U]
 Rep. American Chemistry Council
G. Scott Harding, F. B. Harding, Inc., MD [IM]
 Rep. Independent Electrical Contractors, Inc.
Joseph Harding, Power Tool Institute, OH [M]
William J. Helfrich, U.S. Department of Labor, PA [E]
Paul J. LeVasseur, Bay City JEATC, MI [L]
 Rep. International Brotherhood of Electrical Workers
Charles F. Mello, UL LLC, WA [RT]
Daleep C. Mohla, DCM Electrical Consulting Services, Inc., TX [U]
 Rep. Institute of Electrical & Electronics Engineers, Inc.
Christine T. Porter, Intertek Testing Services, WA [RT]
Gregory J. Steinman, Thomas & Betts Corporation, TN [M]
 Rep. National Electrical Manufacturers Association
Richard Temblador, Southwire Company, GA [M]
 Rep. The Aluminum Association, Inc.
C. Douglas White, CenterPoint Energy, Inc., TX [UT]
 Rep. Electric Light & Power Group/EEI
David A. Williams, Delta Charter Township, MI [E]
 Rep. International Association of Electrical Inspectors

Alternates

Gary A. Beckstrand, Utah Electrical JATC, UT [L]
 (Alt. to Paul J. LeVasseur)
 Rep. International Brotherhood of Electrical Workers
Joseph P. DeGregoria, UL LLC, NY [RT]
 (Alt. to Charles F. Mello)
Jacob M. Howlett, Wilson Construction Company, OR [IM]
 (Alt. to Nathan Philips)
 Rep. National Electrical Contractors Association

Ronald Lai, Burndy LLC, NH [M]
 (Alt. to Gregory J. Steinman)
 Rep. National Electrical Manufacturers Association
Richard E. Loyd, R & N Associates, AZ [M]
 (Alt. to Martin J. Brett, Jr.)
 Rep. American Iron and Steel Institute
Randall R. McCarver, Telcordia Technologies, Inc., NJ [U]
 (Alt. to Trevor N. Bowmer)
 Rep. Alliance for Telecommunications Industry Solutions
Michael E. McNeil, FMC Bio Polymer, ME [U]
 (Alt. to Paul Dobrowsky)
 Rep. American Chemistry Council
Mike O'Meara, Arizona Public Service Company, AZ [UT]
 (Alt. to C. Douglas White)
 Rep. Electric Light & Power Group/EEI
William A. Pancake, III, Universal Engineering Sciences, FL [E]
 (Alt. to David A. Williams)
 Rep. International Association of Electrical Inspectors
Paul R. Picard, AFC Cable Systems, Inc., MA [M]
 (Alt. to Richard Temblador)
 Rep. The Aluminum Association, Inc.
Michael Querry, Trinity River Authority, TX [IM]
 (Alt. to G. Scott Harding)
 Rep. Independent Electrical Contractors, Inc.
Elliot Rappaport, Coconut Creek, FL [U]
 (Alt. to Daleep C. Mohla)
 Rep. Institute of Electrical & Electronics Engineers, Inc.
Phil Simmons, Simmons Electrical Services, WA [M]
 (Alt. to David Brender)
 Rep. Copper Development Association Inc.
Thomas R. Siwek, Robert Bosch Tool Corporation, IL [M]
 (Alt. to Joseph Harding)
 Rep. Power Tool Institute
Fred Song, Intertek Testing Services, China [RT]
 (Alt. to Christine T. Porter)

Nonvoting

Robert A. Nelson, Canadian Standards Association, Canada [RT]

CODE-MAKING PANEL NO. 6

Articles 310, 400, 402, Chapter 9, Tables 5 through 9, and Annex B

Scott Cline, *Chair*

McMurtrey Electric, Inc., CA [IM]

Rep. National Electrical Contractors Association

Samuel B. Friedman, General Cable Corporation, RI [M]
Rep. National Electrical Manufacturers Association

Robert L. Huddleston, Jr., Eastman Chemical Company, TN [U]
Rep. American Chemistry Council

G. W. Kent, Kent Electric & Plumbing Systems, TX [IM]
Rep. Independent Electrical Contractors, Inc.

William F. Laidler, IBEW Local 223 JATC, MA [L]
Rep. International Brotherhood of Electrical Workers

Paul R. Picard, AFC Cable Systems, Inc., MA [M]
Rep. The Aluminum Association, Inc.

Carl Timothy Wall, Alabama Power Company, AL [UT]
Rep. Electric Light & Power Group/EEI

Mario Xerri, UL LLC, NY [RT]

Joseph S. Zimnoch, The Okonite Company, NJ [M]
Rep. Copper Development Association Inc.

Alternates

Peter E. Bowers, Satellite Electric Company, Inc., MD [IM]
(Alt. to G. W. Kent)

Rep. Independent Electrical Contractors, Inc.

John J. Cangemi, UL LLC, NY [RT]
(Alt. to Mario Xerri)

Todd Crisman, K-Electric Company/NJATC, NE [L]
(Alt. to William F. Laidler)

Rep. International Brotherhood of Electrical Workers

Richard A. Holub, The DuPont Company, Inc., DE [U]
(Alt. to Robert L. Huddleston, Jr.)

Rep. American Chemistry Council

Christel K. Hunter, Alcan Cable, NV [M]
(Alt. to Samuel B. Friedman)

Rep. National Electrical Manufacturers Association

Lowell Lisker, AFC Cable Systems, Inc., MA [M]
(Alt. to Paul R. Picard)

Rep. The Aluminum Association, Inc.

Charles David Mercier, Southwire Company, GA [M]
(Alt. to Joseph S. Zimnoch)

Rep. Copper Development Association Inc.

Michael W. Smith, Schaeffer Electric Company, Inc., MO [IM]
(Alt. to Scott Cline)

Rep. National Electrical Contractors Association

John Stacey, City of St. Louis, MO [E]

(Alt. to Richard A. Maddox)

Rep. International Association of Electrical Inspectors

CODE-MAKING PANEL NO. 7

Articles 320, 322, 324, 326, 328, 330, 332, 334, 336, 340, 382, 394, 396, 398, 399

Michael W. Smith, *Chair*

Schaeffer Electric Company, Inc., MO [IM]

Rep. National Electrical Contractors Association

Thomas H. Cybula, UL LLC, NY [RT]

Chris J. Fahrenthold, Facility Solutions Group, TX [IM]
Rep. Independent Electrical Contractors, Inc.

Herman J. Hall, Austin, TX [M]
Rep. The Vinyl Institute

Christel K. Hunter, Alcan Cable, NV [M]
Rep. The Aluminum Association, Inc.

Samuel R. La Dart, City of Memphis, TN [L]
Rep. International Brotherhood of Electrical Workers

Charles David Mercier, Southwire Company, GA [M]
Rep. National Electrical Manufacturers Association

Ronald G. Nickson, National Multi Housing Council, DC [U]
Dennis A. Nielsen, Lawrence Berkeley National Laboratory, CA [U]

Rep. Institute of Electrical & Electronics Engineers, Inc.

Charles J. Palmieri, Town of Norwell, MA [E]
Rep. International Association of Electrical Inspectors

John W. Ray, Duke Energy Corporation, NC [UT]
Rep. Electric Light & Power Group/EEI

Gregory L. Runyon, Eli Lilly and Company, IN [U]
Rep. American Chemistry Council

David E. Schumacher, Associated Builders and Contractors, IA [IM]
Rep. Associated Builders & Contractors

George A. Straniero, AFC Cable Systems, Inc., NJ [M]
Rep. Copper Development Association Inc.

Alternates

J. Richard Barker, General Cable Corporation, CA [M]
(Alt. to Charles David Mercier)

Rep. National Electrical Manufacturers Association

William B. Crist, Houston Stafford Electric Company, TX [IM]
(Alt. to Chris J. Fahrenthold)

Rep. Independent Electrical Contractors, Inc.

Donald G. Dunn, Aramco Services Company, TX [U]
(Alt. to Dennis A. Nielsen)

Rep. Institute of Electrical & Electronics Engineers, Inc.

Rachel E. Krepps, Baltimore Gas & Electric Company, MD [UT]
(Alt. to John W. Ray)

Rep. Electric Light & Power Group/EEI

Keith Owensby, Chattanooga Electrical JATC, TN [L]
(Alt. to Samuel R. La Dart)

Rep. International Brotherhood of Electrical Workers

Kevin T. Porter, Encore Wire Corporation, TX [M]
(Alt. to George A. Straniero)

Rep. Copper Development Association Inc.

Irozenell Pruitt, E. I. DuPont de Nemours & Company, TX [U]
(Alt. to Gregory L. Runyon)

Rep. American Chemistry Council

Susan L. Stene, UL LLC, CA [RT]
(Alt. to Thomas H. Cybula)

Allen R. Turner, James City County, Virginia, VA [E]
(Alt. to Charles J. Palmieri)
Rep. International Association of Electrical Inspectors

Wesley L. Wheeler, Cogburn Bros., Inc., FL [IM]
(Alt. to Michael W. Smith)
Rep. National Electrical Contractors Association

CODE-MAKING PANEL NO. 8

Articles 342, 344, 348, 350, 352, 353, 354, 355, 356, 358, 360, 362, 366, 368, 370, 372, 374, 376, 378, 380, 384, 386, 388, 390, 392, Chapter 9, Tables 1 through 4, Example D13, and Annex C

Larry D. Cogburn, *Chair*
Cogburn Bros., Inc., FL [IM]
Rep. National Electrical Contractors Association

Richard J. Berman, UL LLC, IL [RT]
David M. Campbell, AFC Cable Systems, Inc., MA [M]
Rep. The Aluminum Association, Inc.
Kenneth W. Hengst, EAS Contracting, LP, TX [IM]
Rep. Independent Electrical Contractors, Inc.
James M. Imlah, City of Hillsboro, OR [E]
Rep. International Association of Electrical Inspectors
David H. Kendall, Thomas & Betts Corporation, TN [M]
Rep. The Vinyl Institute
Richard E. Loyd, R & N Associates, AZ [M]
Rep. American Iron and Steel Institute
Michael C. Martin, Lyondellbasell Industries, TX [U]
Rep. American Chemistry Council
Paul W. Myers, PCS Nitrogen, OH [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
Gary W. Pemble, Montana Electrical JATC, MT[L]
Rep. International Brotherhood of Electrical Workers
Rodney J. West, Square D Company/Schneider Electric, OH [M]
Rep. National Electrical Manufacturers Association
Leslie R. Zielke, South Carolina Electric & Gas Company, SC [UT]
Rep. Electric Light & Power Group/EEI

Alternates

Timothy M. Andrea, Southwire Company, GA [M]
(Alt. to David M. Campbell)
Rep. The Aluminum Association, Inc.

George R. Dauberger, Thomas & Betts Corporation, TN [M]
(Alt. to David H. Kendall)
Rep. The Vinyl Institute
David A. Gerstetter, UL LLC, IL [RT]
(Alt. to Richard J. Berman)
Pete Jackson, City of Bakersfield Development Services, CA [E]
(Alt. to James M. Imlah)
Rep. International Association of Electrical Inspectors
Gregory L. Maurer, Wheatland Tube Company, PA [M]
(Alt. to Richard E. Loyd)
Rep. American Iron and Steel Institute
Stephen P. Poholski, Newkirk Electric Associates, Inc., MI [IM]
(Alt. to Larry D. Cogburn)
Rep. National Electrical Contractors Association
Dan Rodriguez, IBEW Local Union 332, CA [L]
(Alt. to Gary W. Pemble)
Rep. International Brotherhood of Electrical Workers
Frederic F. Small, Hubbell Incorporated, CT [M]
(Alt. to Rodney J. West)
Rep. National Electrical Manufacturers Association
Michael K. Weitzel, Central Washington Electrical Education, WA [IM]
(Alt. to Kenneth W. Hengst)
Rep. Independent Electrical Contractors, Inc.

CODE-MAKING PANEL NO. 9

Articles 312, 314, 404, 408, 450, 490

David G. Humphrey, *Chair*
County of Henrico, Virginia, VA [E]
Rep. International Association of Electrical Inspectors

Rodney D. Belisle, NECA-IBEW Electrical Training Trust, OR [L]
Rep. International Brotherhood of Electrical Workers
Kevin J. Breen, Breen Electrical Contractors Inc., NY [IM]
Rep. Independent Electrical Contractors, Inc.
Billy Breitzkreutz, Fluor Corporation, TX [U]
Rep. Associated Builders & Contractors
Wayne Brinkmeyer, Britain Electric Company, TX [IM]
Rep. National Electrical Contractors Association
Paul D. Coghill, Intertek Testing Services, OH [RT]
Frederic P. Hartwell, Hartwell Electrical Services, Inc., MA [SE]
Robert D. Osborne, UL LLC, NC [RT]
Bradford D. Rupp, Allied Moulded Products, Inc., OH [M]
Rep. National Electrical Manufacturers Association
Sukanta Sengupta, FMC Corporation, NJ [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.

Ralph H. Young, Eastman Chemical Company, TN [U]
Rep. American Chemistry Council

Alternates

Gregory A. Bowman, NABCO Electric, TN [IM]
(Alt. to Wayne Brinkmeyer)
Rep. National Electrical Contractors Association
Kenneth S. Crawford, DuPont, WV [U]
(Alt. to Ralph H. Young)
Rep. American Chemistry Council
Jerry M. Ferraro, Northeast Utilities, CT [UT]
(Voting Alt. to ELPG/EEI Rep.)
Rep. Electric Light & Power Group/EEI
L. Keith Lofland, International Association of Electrical Inspectors (IAEI), TX [E]
(Alt. to David G. Humphrey)

Kenneth L. McKinney, Jr., UL LLC, NC [RT]
(Alt. to Robert D. Osborne)
Ronnie H. Ridgeway, Siemens Industry, Inc., TX [M]
(Alt. to Bradford D. Rupp)
Rep. National Electrical Manufacturers Association
Edward Rodriguez, IEC Texas Gulf Coast, TX [IM]
(Alt. to Kevin J. Breen)
Rep. Independent Electrical Contractors, Inc.

Rhett A. Roe, IBEW Local Union 26 JATC, MD [L]
(Alt. to Rodney D. Belisle)
Rep. International Brotherhood of Electrical Workers

CODE-MAKING PANEL NO. 10

Article 240

Julian R. Burns, *Chair*
Quality Power Solutions, Inc., NC [IM]
Rep. Independent Electrical Contractors, Inc.

Scott A. Blizard, American Electrical Testing Company, Inc., MA [IM]
Rep. InterNational Electrical Testing Association
Dennis M. Darling, Stantec, Canada [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
James T. Dollard, Jr., IBEW Local Union 98, PA [L]
Rep. International Brotherhood of Electrical Workers
Carl Fredericks, The Dow Chemical Company, TX [U]
Rep. American Chemistry Council
Jeffrey H. Hidaka, UL LLC, IL [RT]
Robert J. Kauer, Building Inspection Underwriters, Inc., PA [E]
Rep. International Association of Electrical Inspectors
Alan Manche, Square D Company/Schneider Electric, KY [M]
Rep. National Electrical Manufacturers Association
Robert W. Mount, Jr., Hussman Corporation, MO [M]
Rep. Air-Conditioning, Heating, & Refrigeration Institute
George J. Ockuly, Technical Marketing Consultants, MO [M]
Richard Sobel, Quantum Electric Corporation, NY [IM]
Rep. National Electrical Contractors Association
John F. Vartanian, National Grid, MA [UT]
Rep. Electric Light & Power Group/EEI

Alternates

Christopher M. Jensen, North Logan City, UT [E]
(Alt. to Robert J. Kauer)
Rep. International Association of Electrical Inspectors
Frank G. Ladonne, UL LLC, IL [RT]
(Alt. to Jeffrey H. Hidaka)
Kevin J. Lippert, Eaton Corporation, PA [M]
(Alt. to Alan Manche)
Rep. National Electrical Manufacturers Association
Richard E. Lofton, II, IBEW Local Union 280, OR [L]
(Alt. to James T. Dollard, Jr.)
Rep. International Brotherhood of Electrical Workers
Bruce M. Rockwell, American Electrical Testing Company, Inc., NJ [IM]
(Alt. to Scott A. Blizard)
Rep. InterNational Electrical Testing Association
Vincent J. Saporita, Cooper Bussmann, MO [M]
(Alt. to George J. Ockuly)
Roy K. Sparks, III, Elanco Animal Health, IN [U]
(Alt. to Carl Fredericks)
Rep. American Chemistry Council
Steve A. Struble, Freeman's Electric Service, Inc., SD [IM]
(Alt. to Julian R. Burns)
Rep. Independent Electrical Contractors, Inc.
Steven E. Townsend, General Motors Corporation, MI [U]
(Alt. to Dennis M. Darling)
Rep. Institute of Electrical & Electronics Engineers, Inc.

CODE-MAKING PANEL NO. 11

Articles 409, 430, 440, 460, 470, Annex D, Example D8

John M. Thompson, *Chair*
UL LLC, NC [RT]

Luis M. Bas, Intertek Testing Services, FL [RT]
Terry D. Cole, Hamer Electric, Inc., WA [IM]
Rep. Independent Electrical Contractors, Inc.
James M. Fahey, IBEW Local Union 103/MBTA, MA [L]
Rep. International Brotherhood of Electrical Workers
Robert G. Fahey, City of Janesville, WI [E]
Rep. International Association of Electrical Inspectors
Stanley J. Folz, Morse Electric Company, NV [IM]
Rep. National Electrical Contractors Association
Paul E. Guidry, Fluor Enterprises, Inc., TX [U]
Rep. Associated Builders & Contractors
James C. Missildine, Jr., Southern Company Services, Inc., AL [UT]
Rep. Electric Light & Power Group/EEI
Arthur S. Neubauer, Aresal Technologies, GA [U]
Rep. American Petroleum Institute
Charles L. Powell, Eastman Chemical Company, TN [U]
Rep. American Chemistry Council

Vincent J. Saporita, Cooper Bussmann, MO [M]
Arthur J. Smith, III, Waldemar S. Nelson & Company, Inc., LA [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
Ron Widup, Shermco Industries, TX [IM]
Rep. InterNational Electrical Testing Association
James R. Wright, Siemens Industry, Inc., IL [M]
Rep. National Electrical Manufacturers Association

Alternates

Gregory J. Clement, Fluor Enterprises, Inc., TX [U]
(Alt. to Paul E. Guidry)
Rep. Associated Builders & Contractors
Terry W. Cromer, NC Association of Electrical Contractors, NC [IM]
(Alt. to Terry D. Cole)
Rep. Independent Electrical Contractors, Inc.
Jeffrey A. DesJarlais, UL LLC, IL [RT]
(Alt. to John M. Thompson)

Eric Gesualdi, Shell Oil Company, TX [U]
(Alt. to Arthur S. Neubauer)
Rep. American Petroleum Institute
Rodney B. Jones, Clackamas County, Oregon, OR [E]
(Alt. to Robert G. Fahey)
Rep. International Association of Electrical Inspectors
Ed Larsen, Schneider Electric USA, IA [M]
(Alt. to James R. Wright)
Rep. National Electrical Manufacturers Association

Jebediah J. Novak, Cedar Rapids Electrical JATC, IA [L]
(Alt. to James M. Fahey)
Rep. International Brotherhood of Electrical Workers
George J. Ockuly, Technical Marketing Consultants, MO [M]
(Alt. to Vincent J. Saporita)
Bobby A. Walton, Intertek, TX [RT]
(Alt. to Luis M. Bas)

CODE-MAKING PANEL NO. 12

Articles 610, 620, 625, 626, 630, 640, 645, 647, 650, 660, 665, 668, 669, 670, 685, and Annex D, Examples D9 and D10

Timothy M. Croushore, *Chair*
FirstEnergy Technologies, PA [UT]
Rep. Electric Light & Power Group/EEI

Thomas R. Brown, Intertek Testing Services, NY [RT]
Philip Clark, City of Detroit, MI [E]
Rep. International Association of Electrical Inspectors
Karl M. Cunningham, Alcoa, Inc., PA [M]
Rep. The Aluminum Association, Inc.
(VL to 610, 625, 630, 645, 660, 665, 668, 669, 685)
Thomas L. Hedges, Hedges Electric & Construction, Inc., CA [IM]
Rep. National Electrical Contractors Association
Jeffery L. Holmes, IBEW Local Union 1 JATC, MO [L]
Rep. International Brotherhood of Electrical Workers
Angelo G. Horiates, Navy Crane Center, VA [U]
(VL to 610)
Robert E. Johnson, ITE Safety, MA [U]
Rep. Information Technology Industry Council
(VL to 640, 645, 647, 685)
Andy Juhasz, Kone, Inc., IL [M]
Rep. National Elevator Industry Inc.
(VL to 610, 620, 630)
Stanley Kaufman, CableSafe, Inc./OFS, GA [M]
Rep. Society of the Plastics Industry, Inc.
(VL to 640, 645)
John R. Kovacik, UL LLC, IL [RT]
Todd Lottmann, Cooper Bussmann, MO [M]
Rep. National Electrical Manufacturers Association
Jeffrey S. Menig, General Motors Company, MI [U]
Rep. Society of Automotive Engineers-Hybrid Committee
Duke W. Schamel, Electrical Service Solutions, Inc., CA [IM]
Rep. Independent Electrical Contractors, Inc.
Arthur E. Schlueter, Jr., A. E. Schlueter Pipe Organ Company, GA [M]
Rep. American Institute of Organ Builders
(VL to 640, 650)
Robert C. Turner, Inductotherm Corporation, MD [M]
(VL to 610, 630, 665, 668, 669)
Ryan Gregory Ward, IdleAire, Inc., TN [U]
Rep. Transportation Electrification Committee
(VL to 625, 626)
Kenneth White, Olin Corporation, NY [U]
Rep. American Chemistry Council

Alternates

Timothy M. Andrea, Southwire Company, GA [M]
(VL to 610, 625, 630, 645, 660, 665, 668, 669, 685)
(Alt. to Karl M. Cunningham)
Rep. The Aluminum Association, Inc.

Joseph M. Bablo, UL LLC, IL [RT]
(Alt. to John R. Kovacik)
Jeffrey W. Blain, Schindler Elevator Corporation, NY [M]
(VL to 610, 620, 630)
(Alt. to Andy Juhasz)
Rep. National Elevator Industry Inc.
William A. Brunner, Main Electric Construction Inc., ND [IM]
(Alt. to Thomas L. Hedges)
Rep. National Electrical Contractors Association
William B. Crist, Jr., IES Residential Inc., TX [IM]
(Alt. to Duke W. Schamel)
Rep. Independent Electrical Contractors, Inc. Inspectors
Jody B. Greenwood, Navy Crane Center, VA [U]
(VL to 610)
(Alt. to Angelo G. Horiates)
Gery J. Kissel, General Motors Corporation, MI [U]
(Alt. to Jeffrey S. Menig)
Rep. Society of Automotive Engineers-Hybrid Committee
Todd R. Konieczny, Intertek Testing Services, MA [RT]
(Alt. to Thomas R. Brown)
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(VL to 640, 645, 647, 685)
(Alt. to Robert E. Johnson)
Rep. Information Technology Industry Council
Jose A. Salazar, Southern California Edison Company, CA [UT]
(Alt. to Timothy M. Croushore)
Rep. Electric Light & Power Group/EEI
Emad Tabatabaei, Inductotherm Corporation, NJ [M]
(VL to 610, 630, 665, 668, 669)
(Alt. to Robert C. Turner)
Frank Tse, Leviton Manufacturing Company, Inc., NY [M]
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Rep. National Electrical Manufacturers Association
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Nonvoting

Andre R. Cartal, Yardley, PA [E]
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CODE-MAKING PANEL NO. 13

Articles 445, 455, 480, 695, 700, 701, 702, 708, 750, Annex F, and Annex G

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Rep. American Society of Agricultural & Biological Engineers
Neil A. Czarnecki, Reliance Controls Corporation, WI [M]
Rep. National Electrical Manufacturers Association
Herbert H. Daugherty, Electric Generating Systems Association, FL [M]
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Rep. Independent Electrical Contractors, Inc.
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Rep. American Society for Healthcare Engineering
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CODE-MAKING PANEL NO. 14

Articles 500, 501, 502, 503, 504, 505, 506, 510, 511, 513, 514, 515, and 516

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Independent Electrical Contractors, Inc., TX [IM]

Harold G. Alexander, American Electric Power Company, OH [UT]
Rep. Electric Light & Power Group/EEI
Edward M. Briesch, UL LLC, IL [RT]
William T. Fiske, Intertek Testing Services, NY [RT]
Mark Goodman, Hydrogen Energy California LLC, CA [U]
Rep. American Petroleum Institute
Joseph H. Kuczka, Killark Electric Manufacturing Company, MO [M]
Rep. National Electrical Manufacturers Association
William G. Lawrence, Jr., FM Global, MA [I]
L. Evans Massey, Baldor Electric Company, SC [M]
Rep. Instrumentation, Systems, & Automation Society
William E. McBride, Northern Electric Company, AK [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.

Jeremy Neagle, U.S. Bureau of Alcohol, Tobacco, Firearms & Explosives, MD [U]
John L. Simmons, Florida East Coast JATC, FL [L]
Rep. International Brotherhood of Electrical Workers
David B. Wechsler, The Dow Chemical Company, TX [U]
Rep. American Chemistry Council
Mark C. Wirfs, R & W Engineering, Inc., OR [U]
Rep. Grain Elevator and Processing Society

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(Alt. to Joseph H. Kuczka)
Rep. National Electrical Manufacturers Association

Mark W. Bonk, Cargill Incorporated, MN [U]
(Alt. to Mark C. Wirfs)
Rep. Grain Elevator and Processing Society
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Rep. International Brotherhood of Electrical Workers
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(Voting Alt. to ACC Rep.)
(Alt. to David B. Wechsler)
Rep. American Chemistry Council
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(Alt. to Jonathan L. Cadd)

Rep. International Association of Electrical Inspectors
Arkady Levi, Constellation Energy, MD [UT]
(Alt. to Harold G. Alexander)
Rep. Electric Light & Power Group/EEI
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(Alt. to William T. Fiske)
Eddie Ramirez, FM Global, MA [I]
(Alt. to William G. Lawrence, Jr.)
Ted H. Schnaare, Rosemount Incorporated, MN [M]
(Alt. to L. Evans Massey)
Rep. Instrumentation, Systems, & Automation Society

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Timothy J. Pope, Canadian Standards Association, Canada [RT]
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Rep. TC on Airport Facilities

CODE-MAKING PANEL NO. 15

Articles 517, 518, 520, 522, 525, 530, 540

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Intertek Testing Services, KY [RT]

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Rep. Institute of Electrical & Electronics Engineers, Inc.
Douglas S. Erickson, Northstar Management Company,
MO [U]
Rep. American Society for Healthcare Engineering
Kenneth J. Gilbert, Florida Power & Light Company, FL [UT]
Rep. Electric Light & Power Group/EEI
Mitchell K. Hefter, Philips Controls, TX [IM]
Rep. Illuminating Engineering Society of North America
(VL to 518, 520, 525, 530, 540)
Kim Jones, Funtastic Shows, OR [U]
Rep. Outdoor Amusement Business Association, Inc.
(VL to 525)
Edwin S. Kramer, Radio City Music Hall, NY [L]
Rep. International Alliance of Theatrical Stage Employees
(VL to 518, 520, 525, 530, 540)
Gary J. Krupa, U.S. Department of Veterans Affairs, NE [U]
Stephen M. Lipster, The Electrical Trades Center, OH [L]
Rep. International Brotherhood of Electrical Workers
Hugh O. Nash, Jr., Nash-Consult, TN [SE]
Rep. TC on Electrical Systems
Kevin T. Porter, Encore Wire Corporation, TX [M]
Rep. The Aluminum Association, Inc.
Brian E. Rock, Hubbell Incorporated, CT [M]
Rep. National Electrical Manufacturers Association
Marcus R. Sampson, Minnesota Department of Labor
& Industry, MN [E]
Rep. International Association of Electrical Inspectors
James C. Seabury III, Enterprise Electric, LLC, TN [IM]
Rep. Independent Electrical Contractors, Inc.
Bruce D. Shelly, Shelly Electric Company, Inc., PA [IM]
Rep. National Electrical Contractors Association
Michael D. Skinner, CBS Studio Center, CA [U]
Rep. Alliance of Motion Picture and Television Producers
(VL to 518, 520, 525, 530, 540)
Donald J. Talka, UL LLC, NY [RT]
Kenneth E. Vannice, Leviton Manufacturing Company Inc.,
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Rep. U.S. Institute for Theatre Technology
(VL to 518, 520, 525, 530, 540)

Michael Velvikis, High Voltage Maintenance Corporation,
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Rep. InterNational Electrical Testing Association

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Joseph P. Murnane, Jr., UL LLC, NY [RT]
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Steven R. Terry, Electronic Theatre Controls Inc., NY [M]
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Rep. U.S. Institute for Theatre Technology

CODE-MAKING PANEL NO. 16

Articles 770, 800, 810, 820, 830, 840

Thomas E. Moore, Chair
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Rep. International Association of Electrical Inspectors

Donna Ballast, dbi, TX [M]
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George Bish, Secure Watch Security, NC [IM]
Rep. Satellite Broadcasting & Communications Association
J. Robert Boyer, UTC/Edwards Company, NJ [M]
Rep. National Electrical Manufacturers Association
James E. Brunssen, Telcordia, NJ [U]
Rep. Alliance for Telecommunications Industry Solutions
Fred C. Dawson, E. I. Du Pont Canada Company, Canada [U]
Rep. American Chemistry Council
Roland E. Deike, Jr., CenterPoint Energy, Inc., TX [UT]
Rep. Electric Light & Power Group/EEI
Gerald Lee Dorna, Belden Wire & Cable Co., IN [M]
Rep. Insulated Cable Engineers Association Inc
Randolph J. Ivans, UL LLC, NY [RT]
Robert W. Jensen, dbi-Telecommunication Infrastructure Design, TX [M]
Rep. Building Industry Consulting Services International
Steven C. Johnson, Johnson Telecom, LLC, CA [UT]
Rep. National Cable & Telecommunications Association
William J. McCoy, Telco Sales, Inc., TX [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
Michael F. Murphy, Intertek Testing Services, MA [RT]
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Rep. International Brotherhood of Electrical Workers
Thomas J. Parrish, Telgian Corporation, MI [M]
Rep. Automatic Fire Alarm Association, Inc.
W. Douglas Pirkle, Pirkle Electric Company, Inc., GA [IM]
Rep. National Electrical Contractors Association
Luigi G. Prezioso, M. C. Dean, Inc., VA [IM]
Rep. Independent Electrical Contractors, Inc.

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Rep. Alliance for Telecommunications Industry Solutions
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Rep. International Association of Electrical Inspectors
Terry C. Coleman, National Joint Apprentice & Training Committee, TN [L]
(Alt. to Harold C. Ohde)
Rep. International Brotherhood of Electrical Workers
Timothy D. Cooke, Times Fiber Communications, Inc., VA [UT]
(Alt. to Steven C. Johnson)
Rep. National Cable & Telecommunications Association
John A. Kacperski, Tele Design Services, CA [M]
(Alt. to Robert W. Jensen)
Rep. Building Industry Consulting Services International
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Rep. Insulated Cable Engineers Association Inc
David M. Lettkeman, Dish Network Service, LLC, CO [IM]
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Rep. Satellite Broadcasting & Communications Association
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CODE-MAKING PANEL NO. 17

Articles 422, 424, 426, 427, 680, 682

Donald R. Cook, Chair
Shelby County, AL Dept of Development Services, AL [E]
Rep. International Association of Electrical Inspectors

Thomas V. Blewitt, UL LLC, NY [RT]
Randal Hunter, Cooper Bussmann, NV [M]
Rep. National Electrical Manufacturers Association
Don W. Jhonson, Interior Electric, Inc., FL [IM]
Rep. National Electrical Contractors Association
Wayne E. Morris, Association of Home Appliance Manufacturers, DC [M]
(VL to 422, 424)
Jurgen Pannock, Whirlpool Corporation, TN [M]
Rep. Air-Conditioning, Heating, & Refrigeration Institute
(VL to 422, 424)
Marcos Ramirez, Hatfield-Reynolds Electric Company, AZ [IM]
Rep. Independent Electrical Contractors, Inc.
Chester L. Sandberg, Shell Exploration & Production Inc., CA [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.

Ronald F. Schapp, Intertek Testing Services, OH [RT]
Kenneth M. Shell, Tyco Thermal Controls, CA [M]
Rep. Copper Development Association Inc.
(VL to 426, 427)
Ronald Sweigart, E.I. duPont de Nemours & Company, Inc., DE [U]
Rep. American Chemistry Council
(VL to 422, 424, 426, 427, 682)
Lee L. West, Newport Controls, LLC, CA [M]
Rep. Association of Pool & Spa Professionals
(VL to 680)
Randy J. Yasenchak, IBEW Local Union 607, PA [L]
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Alternates

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Rep. Independent Electrical Contractors, Inc.

Ira "Lee" Douglas, Murfreesboro, TN [E]
(Alt. to Donald R. Cook)
Rep. International Association of Electrical Inspectors

E. P. Hamilton, III, E. P. Hamilton & Associates, Inc., TX [M]
(VL to 680)
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Brian Myers, IBEW Local Union 98, PA [L]
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CODE-MAKING PANEL NO. 18

Articles 393, 406, 411, 600, 605

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Rep. Institute of Electrical & Electronics Engineers, Inc.

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Rep. International Brotherhood of Electrical Workers

Hakim Hasan, Intertek Testing Services, GA [RT]

Lee C. Hewitt, UL LLC, IL [RT]

Melvyn J. Kochan, Young Electric Sign Company, NV [M]
Rep. International Sign Association
(VL to 600)

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(VL to 410, 411)

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(Alt. to Frederick L. Carpenter)
Rep. National Electrical Manufacturers Association

Robert T. Carlock, R. T. Carlock Company, TN [IM]
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Rep. Independent Electrical Contractors, Inc.

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(VL to 600)

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CODE-MAKING PANEL NO. 19

Articles 545, 547, 550, 551, 552, 553, 555, 604, 675, and Annex D, Examples D11 and D12

Leslie Sabin-Mercado, *Chair*
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Rep. Electric Light & Power Group/EEI

Barry S. Bauman, Alliant Energy, WI [U]
Rep. American Society of Agricultural & Biological Engineers
Ron B. Chilton, North Carolina Department of Insurance, NC [E]
Rep. International Association of Electrical Inspectors
Timothy Edwards, General Cable/Alcan Cable, GA [M]
Rep. The Aluminum Association, Inc.
Wade Elliott, Utility Services Group, Inc., WA [U]
Rep. National Association of RV Parks & Campgrounds (VL to 550, 551, 552)
Bruce A. Hopkins, Recreation Vehicle Industry Association, VA [M]
(VL to 550, 551, 552)
David W. Johnson, CenTex IEC, TX [IM]
Rep. Independent Electrical Contractors, Inc.
Thomas R. Lichtenstein, UL LLC, IL [RT]
Timothy P. McNeive, Thomas & Betts Corporation, TN [M]
Rep. National Electrical Manufacturers Association
Ronald Michaelis, South Bend & Vicinity Electrical JATC, IN [L]
Rep. International Brotherhood of Electrical Workers
Doug Mulvaney, Campgrounds of America, Inc., MT [U]
(VL to 550, 551, 552, 555)
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Rep. Institute of Electrical & Electronics Engineers, Inc.

Alternates

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(Alt. to David W. Johnson)
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Garry D. Cole, Shelby/Mansfield KOA, OH [U]
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Rep. National Association of RV Parks & Campgrounds (VL to 550, 551, 552)
Chris Fairlee, Campgrounds of America, Inc., MT [U]
(Alt. to Doug Mulvaney)
(VL to 550, 551, 552, 555)
Robert J. Fick, Alliant Energy, WI [U]
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(VL to 550, 551, 552)
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These lists represent the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the front of this book.

Committee Scope: This Committee shall have primary responsibility for documents on minimizing the risk of electricity as a source of electric shock and as a potential ignition source of fires and explosions. It shall also be responsible for text to minimize the propagation of fire and explosions due to electrical installations.

The National Electrical Code Committee proposes for adoption its Report on Proposals to NFPA 70, *National Electrical Code*. NFPA 70-2014 is published in Volume 4 of the 2013 National Fire Codes and is in separate pamphlet form.

This Report has been submitted to letter ballot of the Code-Making Panels of the National Electric Code Committee and the results of the ballot can be found in the Report.

This Report has also been submitted to letter ballot of the Technical Correlating Committee which consists of 12 voting members. It was voted unanimously affirmative to release this Report.

(A) Equipment Type. Equipment used to protect service-entrance conductors shall meet the requirements of Article 490, Part II.

(B) Enclosed Overcurrent Devices. The restriction to 80 percent of the rating for an enclosed overcurrent device for continuous loads shall not apply to overcurrent devices installed in systems operating at over 1000 volts.

230.209 Surge Arresters (Lightning Arresters). Surge arresters installed in accordance with the requirements of Article 280 shall be permitted on each ungrounded overhead service conductor.

230.210 Service Equipment — General Provisions. Service equipment, including instrument transformers, shall conform to Article 490, Part I.

230.211 Switchgear. Switchgear shall consist of a substantial metal structure and a sheet metal enclosure. Where installed over a combustible floor, suitable protection thereto shall be provided.

230.212 Over 35,000 Volts. Where the voltage exceeds 35,000 volts between conductors that enter a building, they shall terminate in a switchgear compartment or a vault conforming to the requirements of 450.41 through 450.48.

ARTICLE 240 Overcurrent Protection

I. General

240.1 Scope. Parts I through VII of this article provide the general requirements for overcurrent protection and overcurrent protective devices not more than 1000 volts, nominal. Part VIII covers overcurrent protection for those portions of supervised industrial installations operating at voltages of not more than 1000 volts, nominal. Part IX covers overcurrent protection over 1000 volts, nominal.

Informational Note: Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation. See also 110.9 for requirements for interrupting ratings and 110.10 for requirements for protection against fault currents.

240.2 Definitions.

Current-Limiting Overcurrent Protective Device. A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the

same circuit if the device were replaced with a solid conductor having comparable impedance.

Supervised Industrial Installation. For the purposes of Part VIII, the industrial portions of a facility where all of the following conditions are met:

- (1) Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system.
- (2) The premises wiring system has 2500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220.
- (3) The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase.

This definition excludes installations in buildings used by the industrial facility for offices, warehouses, garages, machine shops, and recreational facilities that are not an integral part of the industrial plant, substation, or control center.

Tap Conductors. As used in this article, a tap conductor is defined as a conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4.

240.3 Other Articles. Equipment shall be protected against overcurrent in accordance with the article in this *Code* that covers the type of equipment specified in Table 240.3.

240.4 Protection of Conductors. Conductors, other than flexible cords, flexible cables, and fixture wires, shall be protected against overcurrent in accordance with their ampacities specified in 310.15, unless otherwise permitted or required in 240.4(A) through (G).

Informational Note: See ICEA P-32-382-2007 for information on allowable short-circuit currents for insulated copper and aluminum conductors.

(A) Power Loss Hazard. Conductor overload protection shall not be required where the interruption of the circuit would create a hazard, such as in a material-handling magnet circuit or fire pump circuit. Short-circuit protection shall be provided.

Informational Note: See NFPA 20-2013, *Standard for the Installation of Stationary Pumps for Fire Protection*.

(B) Overcurrent Devices Rated 800 Amperes or Less. The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

Table 240.3 Other Articles

Equipment	Article
Air-conditioning and refrigerating equipment	440
Appliances	422
Assembly occupancies	518
Audio signal processing, amplification, and reproduction equipment	640
Branch circuits	210
Busways	368
Capacitors	460
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725
Cranes and hoists	610
Electric signs and outline lighting	600
Electric welders	630
Electrolytic cells	668
Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chairlifts	620
Emergency systems	700
Fire alarm systems	760
Fire pumps	695
Fixed electric heating equipment for pipelines and vessels	427
Fixed electric space-heating equipment	424
Fixed outdoor electric deicing and snow-melting equipment	426
Generators	445
Health care facilities	517
Induction and dielectric heating equipment	665
Industrial machinery	670
Luminaires, lampholders, and lamps	410
Motion picture and television studios and similar locations	530
Motors, motor circuits, and controllers	430
Phase converters	455
Pipe organs	650
Receptacles	406
Services	230
Solar photovoltaic systems	690
Switchboards and panelboards	408
Theaters, audience areas of motion picture and television studios, and similar locations	520
Transformers and transformer vaults	450
X-ray equipment	660

- (1) The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads.
- (2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rat-

ing (but that shall be permitted to have other trip or rating adjustments).

- (3) The next higher standard rating selected does not exceed 800 amperes.

(C) Overcurrent Devices Rated over 800 Amperes.

Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device defined in 240.6.

(D) Small Conductors. Unless specifically permitted in 240.4(E) or (G), the overcurrent protection shall not exceed that required by (D)(1) through (D)(7) after any correction factors for ambient temperature and number of conductors have been applied.

(1) 18 AWG Copper. 7 amperes, provided all the following conditions are met:

- (1) Continuous loads do not exceed 5.6 amperes.
- (2) Overcurrent protection is provided by one of the following:
 - a. Branch-circuit-rated circuit breakers listed and marked for use with 18 AWG copper wire
 - b. Branch-circuit-rated fuses listed and marked for use with 18 AWG copper wire
 - c. Class CC, Class J, or Class T fuses

(2) 16 AWG Copper. 10 amperes, provided all the following conditions are met:

- (1) Continuous loads do not exceed 8 amperes.
- (2) Overcurrent protection is provided by one of the following:
 - a. Branch-circuit-rated circuit breakers listed and marked for use with 16 AWG copper wire
 - b. Branch-circuit-rated fuses listed and marked for use with 16 AWG copper wire
 - c. Class CC, Class J, or Class T fuses

(3) 14 AWG Copper. 15 amperes

(4) 12 AWG Aluminum and Copper-Clad Aluminum. 15 amperes

(5) 12 AWG Copper. 20 amperes

(6) 10 AWG Aluminum and Copper-Clad Aluminum. 25 amperes

(7) 10 AWG Copper. 30 amperes

(E) Tap Conductors. Tap conductors shall be permitted to be protected against overcurrent in accordance with the following:

- (1) 210.19(A)(3) and (A)(4), Household Ranges and Cooking Appliances and Other Loads
- (2) 240.5(B)(2), Fixture Wire

- (3) 240.21, Location in Circuit
- (4) 368.17(B), Reduction in Ampacity Size of Busway
- (5) 368.17(C), Feeder or Branch Circuits (busway taps)
- (6) 430.53(D), Single Motor Taps

(F) Transformer Secondary Conductors. Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors shall not be considered to be protected by the primary overcurrent protective device. Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

(G) Overcurrent Protection for Specific Conductor Applications. Overcurrent protection for the specific conductors shall be permitted to be provided as referenced in Table 240.4(G).

Table 240.4(G) Specific Conductor Applications

Conductor	Article	Section
Air-conditioning and refrigeration equipment circuit conductors	440, Parts III, VI	
Capacitor circuit conductors	460	460.8(B) and 460.25(A)–(D)
Control and instrumentation circuit conductors (Type ITC)	727	727.9
Electric welder circuit conductors	630	630.12 and 630.32
Fire alarm system circuit conductors	760	760.43, 760.45, 760.121, and Chapter 9, Tables 12(A) and 12(B)
Motor-operated appliance circuit conductors	422, Part II	
Motor and motor-control circuit conductors	430, Parts II, III, IV, V, VI, VII	
Phase converter supply conductors	455	455.7
Remote-control, signaling, and power-limited circuit conductors	725	725.43, 725.45, 725.121, and Chapter 9, Tables 11(A) and 11(B)
Secondary tie conductors	450	450.6

240.5 Protection of Flexible Cords, Flexible Cables, and Fixture Wires. Flexible cord and flexible cable, including tinsel cord and extension cords, and fixture wires shall be protected against overcurrent by either 240.5(A) or (B).

(A) Ampacities. Flexible cord and flexible cable shall be protected by an overcurrent device in accordance with their ampacity as specified in Table 400.5(A)(1) and Table 400.5(A)(2). Fixture wire shall be protected against overcurrent in accordance with its ampacity as specified in Table 402.5. Supplementary overcurrent protection, as covered in 240.10, shall be permitted to be an acceptable means for providing this protection.

(B) Branch-Circuit Overcurrent Device. Flexible cord shall be protected, where supplied by a branch circuit, in accordance with one of the methods described in 240.5(B)(1), (B)(3), or (B)(4). Fixture wire shall be protected, where supplied by a branch circuit, in accordance with 240.5(B)(2).

(1) Supply Cord of Listed Appliance or Luminaire. Where flexible cord or tinsel cord is approved for and used with a specific listed appliance or luminaire, it shall be considered to be protected when applied within the appliance or luminaire listing requirements. For the purposes of this section, a luminaire may be either portable or permanent.

(2) Fixture Wire. Fixture wire shall be permitted to be tapped to the branch-circuit conductor of a branch circuit in accordance with the following:

- (1) 20-ampere circuits — 18 AWG, up to 15 m (50 ft) of run length
- (2) 20-ampere circuits — 16 AWG, up to 30 m (100 ft) of run length
- (3) 20-ampere circuits — 14 AWG and larger
- (4) 30-ampere circuits — 14 AWG and larger
- (5) 40-ampere circuits — 12 AWG and larger
- (6) 50-ampere circuits — 12 AWG and larger

(3) Extension Cord Sets. Flexible cord used in listed extension cord sets shall be considered to be protected when applied within the extension cord listing requirements.

(4) Field Assembled Extension Cord Sets. Flexible cord used in extension cords made with separately listed and installed components shall be permitted to be supplied by a branch circuit in accordance with the following:
20-ampere circuits — 16 AWG and larger

240.6 Standard Ampere Ratings.

(A) Fuses and Fixed-Trip Circuit Breakers. The standard ampere ratings for fuses and inverse time circuit breakers shall be considered 15, 20, 25, 30, 35, 40, 45, 50,

60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes. Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.

(B) Adjustable-Trip Circuit Breakers. The rating of adjustable-trip circuit breakers having external means for adjusting the current setting (long-time pickup setting), not meeting the requirements of 240.6(C), shall be the maximum setting possible.

(C) Restricted Access Adjustable-Trip Circuit Breakers. A circuit breaker(s) that has restricted access to the adjusting means shall be permitted to have an ampere rating(s) that is equal to the adjusted current setting (long-time pickup setting). Restricted access shall be defined as located behind one of the following:

- (1) Removable and sealable covers over the adjusting means
- (2) Bolted equipment enclosure doors
- (3) Locked doors accessible only to qualified personnel

240.8 Fuses or Circuit Breakers in Parallel. Fuses and circuit breakers shall be permitted to be connected in parallel where they are factory assembled in parallel and listed as a unit. Individual fuses, circuit breakers, or combinations thereof shall not otherwise be connected in parallel.

240.9 Thermal Devices. Thermal relays and other devices not designed to open short circuits or ground faults shall not be used for the protection of conductors against overcurrent due to short circuits or ground faults, but the use of such devices shall be permitted to protect motor branch-circuit conductors from overload if protected in accordance with 430.40.

240.10 Supplementary Overcurrent Protection. Where supplementary overcurrent protection is used for luminaires, appliances, and other equipment or for internal circuits and components of equipment, it shall not be used as a substitute for required branch-circuit overcurrent devices or in place of the required branch-circuit protection. Supplementary overcurrent devices shall not be required to be readily accessible.

240.12 Electrical System Coordination. Where an orderly shutdown is required to minimize the hazard(s) to personnel and equipment, a system of coordination based on the following two conditions shall be permitted:

- (1) Coordinated short-circuit protection
- (2) Overload indication based on monitoring systems or devices

Informational Note: The monitoring system may cause the condition to go to alarm, allowing corrective action or an orderly shutdown, thereby minimizing personnel hazard and equipment damage.

240.13 Ground-Fault Protection of Equipment. Ground-fault protection of equipment shall be provided in accordance with the provisions of 230.95 for solidly grounded wye electrical systems of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for each individual device used as a building or structure main disconnecting means rated 1000 amperes or more.

The provisions of this section shall not apply to the disconnecting means for the following:

- (1) Continuous industrial processes where a nonorderly shutdown will introduce additional or increased hazards
- (2) Installations where ground-fault protection is provided by other requirements for services or feeders
- (3) Fire pumps

240.15 Ungrounded Conductors.

(A) Overcurrent Device Required. A fuse or an overcurrent trip unit of a circuit breaker shall be connected in series with each ungrounded conductor. A combination of a current transformer and overcurrent relay shall be considered equivalent to an overcurrent trip unit.

Informational Note: For motor circuits, see Parts III, IV, V, and XI of Article 430.

(B) Circuit Breaker as Overcurrent Device. Circuit breakers shall open all ungrounded conductors of the circuit both manually and automatically unless otherwise permitted in 240.15(B)(1), (B)(2), (B)(3), and (B)(4).

(1) Multiwire Branch Circuits. Individual single-pole circuit breakers, with identified handle ties, shall be permitted as the protection for each ungrounded conductor of multiwire branch circuits that serve only single-phase line-to-neutral loads.

(2) Grounded Single-Phase Alternating-Current Circuits. In grounded systems, individual single-pole circuit breakers rated 120/240 volts ac, with identified handle ties, shall be permitted as the protection for each ungrounded conductor for line-to-line connected loads for single-phase circuits.

(3) 3-Phase and 2-Phase Systems. For line-to-line loads in 4-wire, 3-phase systems or 5-wire, 2-phase systems, individual single-pole circuit breakers rated 120/240 volts ac with identified handle ties shall be permitted as the protection for each ungrounded conductor, if the systems have a grounded neutral point and the voltage to ground does not exceed 120 volts.

(4) 3-Wire Direct-Current Circuits. Individual single-pole circuit breakers rated 125/250 volts dc with identified handle ties shall be permitted as the protection for each ungrounded conductor for line-to-line connected loads for 3-wire, direct-current circuits supplied from a system with a grounded neutral where the voltage to ground does not exceed 125 volts.

II. Location

240.21 Location in Circuit. Overcurrent protection shall be provided in each ungrounded circuit conductor and shall be located at the point where the conductors receive their supply except as specified in 240.21(A) through (H). Conductors supplied under the provisions of 240.21(A) through (H) shall not supply another conductor except through an overcurrent protective device meeting the requirements of 240.4.

(A) Branch-Circuit Conductors. Branch-circuit tap conductors meeting the requirements specified in 210.19 shall be permitted to have overcurrent protection as specified in 210.20.

(B) Feeder Taps. Conductors shall be permitted to be tapped, without overcurrent protection at the tap, to a feeder as specified in 240.21(B)(1) through (B)(5). The provisions of 240.4(B) shall not be permitted for tap conductors.

(1) Taps Not over 3 m (10 ft) Long. If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

- (1) The ampacity of the tap conductors is
 - a. Not less than the combined calculated loads on the circuits supplied by the tap conductors, and
 - b. Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors.

Exception to b: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

- (2) The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (3) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.
- (4) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampac-

ity of the tap conductors is not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

(2) Taps Not over 7.5 m (25 ft) Long. Where the length of the tap conductors does not exceed 7.5 m (25 ft) and the tap conductors comply with all the following:

- (1) The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.
- (2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(3) Taps Supplying a Transformer [Primary Plus Secondary Not over 7.5 m (25 ft) Long]. Where the tap conductors supply a transformer and comply with all the following conditions:

- (1) The conductors supplying the primary of a transformer have an ampacity at least one-third the rating of the overcurrent device protecting the feeder conductors.
- (2) The conductors supplied by the secondary of the transformer shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the feeder conductors.
- (3) The total length of one primary plus one secondary conductor, excluding any portion of the primary conductor that is protected at its ampacity, is not over 7.5 m (25 ft).
- (4) The primary and secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
- (5) The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.15.

(4) Taps over 7.5 m (25 ft) Long. Where the feeder is in a high bay manufacturing building over 11 m (35 ft) high at walls and the installation complies with all the following conditions:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The tap conductors are not over 7.5 m (25 ft) long horizontally and not over 30 m (100 ft) total length.

- (3) The ampacity of the tap conductors is not less than one-third the rating of the overcurrent device protecting the feeder conductors.
- (4) The tap conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (5) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
- (6) The tap conductors are continuous from end-to-end and contain no splices.
- (7) The tap conductors are sized 6 AWG copper or 4 AWG aluminum or larger.
- (8) The tap conductors do not penetrate walls, floors, or ceilings.
- (9) The tap is made no less than 9 m (30 ft) from the floor.

(5) Outside Taps of Unlimited Length. Where the conductors are located outside of a building or structure, except at the point of load termination, and comply with all of the following conditions:

- (1) The tap conductors are protected from physical damage in an approved manner.
- (2) The tap conductors terminate at a single circuit breaker or a single set of fuses that limits the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The overcurrent device for the tap conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
- (4) The disconnecting means for the tap conductors is installed at a readily accessible location complying with one of the following:
 - a. Outside of a building or structure
 - b. Inside, nearest the point of entrance of the tap conductors
 - c. Where installed in accordance with 230.6, nearest the point of entrance of the tap conductors

(C) Transformer Secondary Conductors. A set of conductors feeding a single load, or each set of conductors feeding separate loads, shall be permitted to be connected to a transformer secondary, without overcurrent protection at the secondary, as specified in 240.21(C)(1) through (C)(6). The provisions of 240.4(B) shall not be permitted for transformer secondary conductors.

Informational Note: For overcurrent protection requirements for transformers, see 450.3.

(1) Protection by Primary Overcurrent Device. Conductors supplied by the secondary side of a single-phase trans-

former having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors are not considered to be protected by the primary overcurrent protective device.

(2) Transformer Secondary Conductors Not over 3 m (10 ft) Long. If the length of secondary conductor does not exceed 3 m (10 ft) and complies with all of the following:

- (1) The ampacity of the secondary conductors is
 - a. Not less than the combined calculated loads on the circuits supplied by the secondary conductors, and
 - b. Not less than the rating of the equipment containing an overcurrent device(s) supplied by the secondary conductors or not less than the rating of the overcurrent protective device at the termination of the secondary conductors.

Exception: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

- (2) The secondary conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (3) The secondary conductors are enclosed in a raceway, which shall extend from the transformer to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices or to the back of an open switchboard.
- (4) For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

(3) Industrial Installation Secondary Conductors Not over 7.5 m (25 ft) Long. For the supply of switchgear or switchboards in industrial installations only, where the length of the secondary conductors does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
- (3) All overcurrent devices are grouped.
- (4) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(4) Outside Secondary Conductors. Where the conductors are located outdoors of a building or structure, except at the point of load termination, and comply with all of the following conditions:

- (1) The conductors are protected from physical damage in an approved manner.
- (2) The conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
- (4) The disconnecting means for the conductors is installed at a readily accessible location complying with one of the following:
 - a. Outside of a building or structure
 - b. Inside, nearest the point of entrance of the conductors
 - c. Where installed in accordance with 230.6, nearest the point of entrance of the conductors

(5) Secondary Conductors from a Feeder Tapped Transformer. Transformer secondary conductors installed in accordance with 240.21(B)(3) shall be permitted to have overcurrent protection as specified in that section.

(6) Secondary Conductors Not over 7.5 m (25 ft) Long. Where the length of secondary conductor does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) The secondary conductors shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the primary of the transformer.
- (2) The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.15.
- (3) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(D) Service Conductors. Service conductors shall be permitted to be protected by overcurrent devices in accordance with 230.91.

(E) Busway Taps. Busways and busway taps shall be permitted to be protected against overcurrent in accordance with 368.17.

(F) Motor Circuit Taps. Motor-feeder and branch-circuit conductors shall be permitted to be protected against overcurrent in accordance with 430.28 and 430.53, respectively.

(G) Conductors from Generator Terminals. Conductors from generator terminals that meet the size requirement in 445.13 shall be permitted to be protected against overload by the generator overload protective device(s) required by 445.12.

(H) Battery Conductors. Overcurrent protection shall be permitted to be installed as close as practicable to the storage battery terminals in an unclassified location. Installation of the overcurrent protection within a hazardous (classified) location shall also be permitted.

240.22 Grounded Conductor. No overcurrent device shall be connected in series with any conductor that is intentionally grounded, unless one of the following two conditions is met:

- (1) The overcurrent device opens all conductors of the circuit, including the grounded conductor, and is designed so that no pole can operate independently.
- (2) Where required by 430.36 or 430.37 for motor overload protection.

240.23 Change in Size of Grounded Conductor. Where a change occurs in the size of the ungrounded conductor, a similar change shall be permitted to be made in the size of the grounded conductor.

240.24 Location in or on Premises.

(A) Accessibility. Overcurrent devices shall be readily accessible and shall be installed so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 2.0 m (6 ft 7 in.) above the floor or working platform, unless one of the following applies:

- (1) For busways, as provided in 368.17(C).
- (2) For supplementary overcurrent protection, as described in 240.10.
- (3) For overcurrent devices, as described in 225.40 and 230.92.
- (4) For overcurrent devices adjacent to utilization equipment that they supply, access shall be permitted to be by portable means.

(B) Occupancy. Each occupant shall have ready access to all overcurrent devices protecting the conductors supplying that occupancy, unless otherwise permitted in 240.24(B)(1) and (B)(2).

(1) Service and Feeder Overcurrent Devices. Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the service overcurrent devices and feeder overcurrent devices supplying more than one occupancy shall be permitted to be accessible only to authorized management personnel in the following:

- (1) Multiple-occupancy buildings
- (2) Guest rooms or guest suites

(2) Branch-Circuit Overcurrent Devices. Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the branch-circuit overcurrent devices supplying any guest rooms or guest suites without permanent provisions for cooking shall be permitted to be accessible only to authorized management personnel.

(C) Not Exposed to Physical Damage. Overcurrent devices shall be located where they will not be exposed to physical damage.

Informational Note: See 110.11, Deteriorating Agents.

(D) Not in Vicinity of Easily Ignitable Material. Overcurrent devices shall not be located in the vicinity of easily ignitable material, such as in clothes closets.

(E) Not Located in Bathrooms. In dwelling units, dormitories, and guest rooms or guest suites, overcurrent devices, other than supplementary overcurrent protection, shall not be located in bathrooms.

(F) Not Located over Steps. Overcurrent devices shall not be located over steps of a stairway.

III. Enclosures

240.30 General.

(A) Protection from Physical Damage. Overcurrent devices shall be protected from physical damage by one of the following:

- (1) Installation in enclosures, cabinets, cutout boxes, or equipment assemblies
- (2) Mounting on open-type switchboards, panelboards, or control boards that are in rooms or enclosures free from dampness and easily ignitable material and are accessible only to qualified personnel

(B) Operating Handle. The operating handle of a circuit breaker shall be permitted to be accessible without opening a door or cover.

240.32 Damp or Wet Locations. Enclosures for overcurrent devices in damp or wet locations shall comply with 312.2.

240.33 Vertical Position. Enclosures for overcurrent devices shall be mounted in a vertical position unless that is shown to be impracticable. Circuit breaker enclosures shall be permitted to be installed horizontally where the circuit breaker is installed in accordance with 240.81. Listed busway plug-in units shall be permitted to be mounted in orientations corresponding to the busway mounting position.

IV. Disconnecting and Guarding

240.40 Disconnecting Means for Fuses. Cartridge fuses in circuits of any voltage where accessible to other than qualified persons, and all fuses in circuits over 150 volts to ground, shall be provided with a disconnecting means on their supply side so that each circuit containing fuses can be independently disconnected from the source of power. A current-limiting device without a disconnecting means shall be permitted on the supply side of the service disconnecting means as permitted by 230.82. A single disconnecting means shall be permitted on the supply side of more than one set of fuses as permitted by 430.112, Exception, for group operation of motors and 424.22(C) for fixed electric space-heating equipment.

240.41 Arcing or Suddenly Moving Parts. Arcing or suddenly moving parts shall comply with 240.41(A) and (B).

(A) Location. Fuses and circuit breakers shall be located or shielded so that persons will not be burned or otherwise injured by their operation.

(B) Suddenly Moving Parts. Handles or levers of circuit breakers, and similar parts that may move suddenly in such a way that persons in the vicinity are likely to be injured by being struck by them, shall be guarded or isolated.

V. Plug Fuses, Fuseholders, and Adapters

240.50 General.

(A) Maximum Voltage. Plug fuses shall be permitted to be used in the following circuits:

- (1) Circuits not exceeding 125 volts between conductors
- (2) Circuits supplied by a system having a grounded neutral point where the line-to-neutral voltage does not exceed 150 volts

(B) Marking. Each fuse, fuseholder, and adapter shall be marked with its ampere rating.

(C) Hexagonal Configuration. Plug fuses of 15-ampere and lower rating shall be identified by a hexagonal configuration of the window, cap, or other prominent part to distinguish them from fuses of higher ampere ratings.

(D) No Energized Parts. Plug fuses, fuseholders, and adapters shall have no exposed energized parts after fuses or fuses and adapters have been installed.

(E) Screw Shell. The screw shell of a plug-type fuseholder shall be connected to the load side of the circuit.

240.51 Edison-Base Fuses.

(A) Classification. Plug fuses of the Edison-base type shall be classified at not over 125 volts and 30 amperes and below.

(B) Replacement Only. Plug fuses of the Edison-base type shall be used only for replacements in existing installations where there is no evidence of overfusing or tampering.

240.52 Edison-Base Fuseholders. Fuseholders of the Edison-base type shall be installed only where they are made to accept Type S fuses by the use of adapters.

240.53 Type S Fuses. Type S fuses shall be of the plug type and shall comply with 240.53(A) and (B).

(A) Classification. Type S fuses shall be classified at not over 125 volts and 0 to 15 amperes, 16 to 20 amperes, and 21 to 30 amperes.

(B) Noninterchangeable. Type S fuses of an ampere classification as specified in 240.53(A) shall not be interchangeable with a lower ampere classification. They shall be designed so that they cannot be used in any fuseholder other than a Type S fuseholder or a fuseholder with a Type S adapter inserted.

240.54 Type S Fuses, Adapters, and Fuseholders.

(A) To Fit Edison-Base Fuseholders. Type S adapters shall fit Edison-base fuseholders.

(B) To Fit Type S Fuses Only. Type S fuseholders and adapters shall be designed so that either the fuseholder itself or the fuseholder with a Type S adapter inserted cannot be used for any fuse other than a Type S fuse.

(C) Nonremovable. Type S adapters shall be designed so that once inserted in a fuseholder, they cannot be removed.

(D) Nontamperable. Type S fuses, fuseholders, and adapters shall be designed so that tampering or shunting (bridging) would be difficult.

(E) Interchangeability. Dimensions of Type S fuses, fuseholders, and adapters shall be standardized to permit interchangeability regardless of the manufacturer.

VI. Cartridge Fuses and Fuseholders

240.60 General.

(A) Maximum Voltage — 300-Volt Type. Cartridge fuses and fuseholders of the 300-volt type shall be permitted to be used in the following circuits:

- (1) Circuits not exceeding 300 volts between conductors
- (2) Single-phase line-to-neutral circuits supplied from a 3-phase, 4-wire, solidly grounded neutral source where the line-to-neutral voltage does not exceed 300 volts

(B) Noninterchangeable — 0–6000-Ampere Cartridge Fuseholders. Fuseholders shall be designed so that it will be difficult to put a fuse of any given class into a fuseholder that is designed for a current lower, or voltage higher, than that of the class to which the fuse belongs. Fuseholders for current-limiting fuses shall not permit insertion of fuses that are not current-limiting.

(C) Marking. Fuses shall be plainly marked, either by printing on the fuse barrel or by a label attached to the barrel showing the following:

- (1) Ampere rating
- (2) Voltage rating
- (3) Interrupting rating where other than 10,000 amperes
- (4) Current limiting where applicable
- (5) The name or trademark of the manufacturer

The interrupting rating shall not be required to be marked on fuses used for supplementary protection.

(D) Renewable Fuses. Class H cartridge fuses of the renewable type shall be permitted to be used only for replacement in existing installations where there is no evidence of overfusing or tampering.

240.61 Classification. Cartridge fuses and fuseholders shall be classified according to voltage and amperage ranges. Fuses rated 1000 volts, nominal, or less shall be permitted to be used for voltages at or below their ratings.

VII. Circuit Breakers

240.80 Method of Operation. Circuit breakers shall be trip free and capable of being closed and opened by manual operation. Their normal method of operation by other than manual means, such as electrical or pneumatic, shall be permitted if means for manual operation are also provided.

240.81 Indicating. Circuit breakers shall clearly indicate whether they are in the open “off” or closed “on” position.

Where circuit breaker handles are operated vertically rather than rotationally or horizontally, the “up” position of the handle shall be the “on” position.

240.82 Nontamperable. A circuit breaker shall be of such design that any alteration of its trip point (calibration) or the time required for its operation requires dismantling of the device or breaking of a seal for other than intended adjustments.

240.83 Marking.

(A) Durable and Visible. Circuit breakers shall be marked with their ampere rating in a manner that will be durable and visible after installation. Such marking shall be permitted to be made visible by removal of a trim or cover.

(B) Location. Circuit breakers rated at 100 amperes or less and 1000 volts or less shall have the ampere rating molded, stamped, etched, or similarly marked into their handles or escutcheon areas.

(C) Interrupting Rating. Every circuit breaker having an interrupting rating other than 5000 amperes shall have its interrupting rating shown on the circuit breaker. The interrupting rating shall not be required to be marked on circuit breakers used for supplementary protection.

(D) Used as Switches. Circuit breakers used as switches in 120-volt and 277-volt fluorescent lighting circuits shall be listed and shall be marked SWD or HID. Circuit breakers used as switches in high-intensity discharge lighting circuits shall be listed and shall be marked as HID.

(E) Voltage Marking. Circuit breakers shall be marked with a voltage rating not less than the nominal system voltage that is indicative of their capability to interrupt fault currents between phases or phase to ground.

240.85 Applications. A circuit breaker with a straight voltage rating, such as 240V or 480V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker’s voltage rating. A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked $1\phi-3\phi$ to indicate such suitability.

A circuit breaker with a slash rating, such as 120/240V or 480Y/277V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker’s voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker’s voltage rating.

Informational Note: Proper application of molded case circuit breakers on 3-phase systems, other than solidly

grounded wye, particularly on corner grounded delta systems, considers the circuit breakers’ individual pole-interrupting capability.

240.86 Series Ratings. Where a circuit breaker is used on a circuit having an available fault current higher than the marked interrupting rating by being connected on the load side of an acceptable overcurrent protective device having a higher rating, the circuit breaker shall meet the requirements specified in (A) or (B), and (C).

(A) Selected Under Engineering Supervision in Existing Installations. The series rated combination devices shall be selected by a licensed professional engineer engaged primarily in the design or maintenance of electrical installations. The selection shall be documented and stamped by the professional engineer. This documentation shall be available to those authorized to design, install, inspect, maintain, and operate the system. This series combination rating, including identification of the upstream device, shall be field marked on the end use equipment.

For calculated applications, the engineer shall ensure that the downstream circuit breaker(s) that are part of the series combination remain passive during the interruption period of the line side fully rated, current-limiting device.

(B) Tested Combinations. The combination of line-side overcurrent device and load-side circuit breaker(s) is tested and marked on the end use equipment, such as switchboards and panelboards.

Informational Note to (A) and (B): See 110.22 for marking of series combination systems.

(C) Motor Contribution. Series ratings shall not be used where

- (1) Motors are connected on the load side of the higher-rated overcurrent device and on the line side of the lower-rated overcurrent device, and
- (2) The sum of the motor full-load currents exceeds 1 percent of the interrupting rating of the lower-rated circuit breaker.

240.87 Arc Energy Reduction. Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200 A or higher, 240.87(A) and (B) shall apply.

(A) Documentation. Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s).

(B) Method to Reduce Clearing Time. One of the following or approved equivalent means shall be provided:

- (1) Zone-selective interlocking
- (2) Differential relaying

- (3) Energy-reducing maintenance switching with local status indicator
- (4) Energy-reducing active arc flash mitigation system
- (5) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to “no intentional delay” to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2012, Standard for Electrical Safety in the Workplace*, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc flash boundary as defined in *NFPA 70E-2012, Standard for Electrical Safety in the Workplace*.

VIII. Supervised Industrial Installations

240.90 General. Overcurrent protection in areas of supervised industrial installations shall comply with all of the other applicable provisions of this article, except as provided in Part VIII. The provisions of Part VIII shall be permitted only to apply to those portions of the electrical system in the supervised industrial installation used exclusively for manufacturing or process control activities.

240.91 Protection of Conductors. Conductors shall be protected in accordance with 240.91(A) or (B).

(A) General. Conductors shall be protected in accordance with 240.4.

(B) Devices Rated Over 800 Amperes. Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than 95 percent of the rating of the overcurrent device specified in 240.6 in accordance with (B)(1) and (2).

- (1) The conductors are protected within recognized time vs. current limits for short-circuit currents
- (2) All equipment in which the conductors terminate is listed and marked for the application

240.92 Location in Circuit. An overcurrent device shall be connected in each ungrounded circuit conductor as required in 240.92(A) through (E).

(A) Feeder and Branch-Circuit Conductors. Feeder and branch-circuit conductors shall be protected at the point the conductors receive their supply as permitted in 240.21 or as otherwise permitted in 240.92(B), (C), (D), or (E).

(B) Feeder Taps. For feeder taps specified in 240.21(B)(2), (B)(3), and (B)(4), the tap conductors shall be permitted to be sized in accordance with Table 240.92(B).

Table 240.92(B) Tap Conductor Short-Circuit Current Ratings.

Tap conductors are considered to be protected under short-circuit conditions when their short-circuit temperature limit is not exceeded. Conductor heating under short-circuit conditions is determined by (1) or (2):

- (1) *Short-Circuit Formula for Copper Conductors*

$$(I^2/A^2)t = 0.0297 \log_{10} [(T_2 + 234)/(T_1 + 234)]$$

- (2) *Short-Circuit Formula for Aluminum Conductors*

$$(I^2/A^2)t = 0.0125 \log_{10} [(T_2 + 228)/(T_1 + 228)]$$

where:

I = short-circuit current in amperes

A = conductor area in circular mils

t = time of short circuit in seconds (for times less than or equal to 10 seconds)

T_1 = initial conductor temperature in degrees Celsius.

T_2 = final conductor temperature in degrees Celsius.

Copper conductor with paper, rubber, varnished cloth insulation,
 $T_2 = 200$

Copper conductor with thermoplastic insulation, $T_2 = 150$

Copper conductor with cross-linked polyethylene insulation, $T_2 = 250$

Copper conductor with ethylene propylene rubber insulation, $T_2 = 250$

Aluminum conductor with paper, rubber, varnished cloth insulation, $T_2 = 200$

Aluminum conductor with thermoplastic insulation, $T_2 = 150$

Aluminum conductor with cross-linked polyethylene insulation, $T_2 = 250$

Aluminum conductor with ethylene propylene rubber insulation, $T_2 = 250$

(C) Transformer Secondary Conductors of Separately Derived Systems. Conductors shall be permitted to be connected to a transformer secondary of a separately derived system, without overcurrent protection at the connection, where the conditions of 240.92(C)(1), (C)(2), and (C)(3) are met.

(1) Short-Circuit and Ground-Fault Protection. The conductors shall be protected from short-circuit and ground-fault conditions by complying with one of the following conditions:

- (1) The length of the secondary conductors does not exceed 30 m (100 ft) and the transformer primary overcurrent device has a rating or setting that does not exceed 150 percent of the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.
- (2) The conductors are protected by a differential relay with a trip setting equal to or less than the conductor ampacity.

Informational Note: A differential relay is connected to be sensitive only to short-circuit or fault currents within the protected zone and is normally set much lower than the conductor ampacity. The differential relay is connected to trip protective devices that de-energize the protected conductors if a short-circuit condition occurs.

- (3) The conductors shall be considered to be protected if calculations, made under engineering supervision, determine that the system overcurrent devices will protect the conductors within recognized time vs. current limits for all short-circuit and ground-fault conditions.

(2) Overload Protection. The conductors shall be protected against overload conditions by complying with one of the following:

- (1) The conductors terminate in a single overcurrent device that will limit the load to the conductor ampacity.
- (2) The sum of the overcurrent devices at the conductor termination limits the load to the conductor ampacity. The overcurrent devices shall consist of not more than six circuit breakers or sets of fuses mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard or switchgear. There shall be no more than six overcurrent devices grouped in any one location.
- (3) Overcurrent relaying is connected [with a current transformer(s), if needed] to sense all of the secondary conductor current and limit the load to the conductor ampacity by opening upstream or downstream devices.
- (4) Conductors shall be considered to be protected if calculations, made under engineering supervision, determine that the system overcurrent devices will protect the conductors from overload conditions.

(3) Physical Protection. The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(D) Outside Feeder Taps. Outside conductors shall be permitted to be tapped to a feeder or to be connected at a transformer secondary, without overcurrent protection at the tap or connection, where all the following conditions are met:

- (1) The conductors are protected from physical damage in an approved manner.
- (2) The sum of the overcurrent devices at the conductor termination limits the load to the conductor ampacity.

The overcurrent devices shall consist of not more than six circuit breakers or sets of fuses mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard or switchgear. There shall be no more than six overcurrent devices grouped in any one location.

- (3) The tap conductors are installed outdoors of a building or structure except at the point of load termination.
- (4) The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
- (5) The disconnecting means for the conductors are installed at a readily accessible location complying with one of the following:
 - a. Outside of a building or structure
 - b. Inside, nearest the point of entrance of the conductors
 - c. Where installed in accordance with 230.6, nearest the point of entrance of the conductors

(E) Protection by Primary Overcurrent Device. Conductors supplied by the secondary side of a transformer shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided the primary device time-current protection characteristic, multiplied by the maximum effective primary-to-secondary transformer voltage ratio, effectively protects the secondary conductors.

IX. Overcurrent Protection over 1000 Volts, Nominal

240.100 Feeders and Branch Circuits.

(A) Location and Type of Protection. Feeder and branch-circuit conductors shall have overcurrent protection in each ungrounded conductor located at the point where the conductor receives its supply or at an alternative location in the circuit when designed under engineering supervision that includes but is not limited to considering the appropriate fault studies and time-current coordination analysis of the protective devices and the conductor damage curves. The overcurrent protection shall be permitted to be provided by either 240.100(A)(1) or (A)(2).

(1) Overcurrent Relays and Current Transformers. Circuit breakers used for overcurrent protection of 3-phase circuits shall have a minimum of three overcurrent relay elements operated from three current transformers. The separate overcurrent relay elements (or protective functions) shall be permitted to be part of a single electronic protective relay unit.

On 3-phase, 3-wire circuits, an overcurrent relay element in the residual circuit of the current transformers shall be permitted to replace one of the phase relay elements.

An overcurrent relay element, operated from a current transformer that links all phases of a 3-phase, 3-wire circuit, shall be permitted to replace the residual relay element and one of the phase-conductor current transformers.

Where the neutral conductor is not regrounded on the load side of the circuit as permitted in 250.184(B), the current transformer shall be permitted to link all 3-phase conductors and the grounded circuit conductor (neutral).

(2) Fuses. A fuse shall be connected in series with each ungrounded conductor.

(B) Protective Devices. The protective device(s) shall be capable of detecting and interrupting all values of current that can occur at their location in excess of their trip-setting or melting point.

(C) Conductor Protection. The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.

240.101 Additional Requirements for Feeders.

(A) Rating or Setting of Overcurrent Protective Devices. The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors. The long-time trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse shall not exceed six times the ampacity of the conductor. For fire pumps, conductors shall be permitted to be protected for overcurrent in accordance with 695.4(B)(2).

(B) Feeder Taps. Conductors tapped to a feeder shall be permitted to be protected by the feeder overcurrent device where that overcurrent device also protects the tap conductor.

Informational Note: See Figure 250.1 for information on the organization of Article 250 covering grounding and bonding requirements.

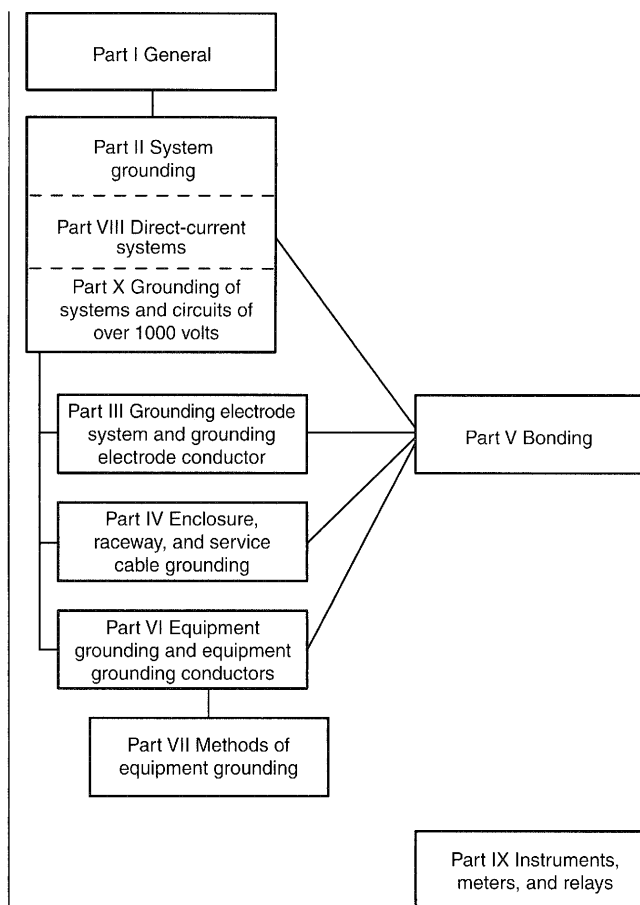


Figure 250.1 Grounding and Bonding.

ARTICLE 250 Grounding and Bonding

I. General

250.1 Scope. This article covers general requirements for grounding and bonding of electrical installations, and the specific requirements in (1) through (6).

- (1) Systems, circuits, and equipment required, permitted, or not permitted to be grounded
- (2) Circuit conductor to be grounded on grounded systems
- (3) Location of grounding connections
- (4) Types and sizes of grounding and bonding conductors and electrodes
- (5) Methods of grounding and bonding
- (6) Conditions under which guards, isolation, or insulation may be substituted for grounding

250.2 Definition.

Bonding Jumper, Supply-Side. A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected.

250.3 Application of Other Articles. For other articles applying to particular cases of installation of conductors and equipment, grounding and bonding requirements are identified in Table 250.3 that are in addition to, or modifications of, those of this article.

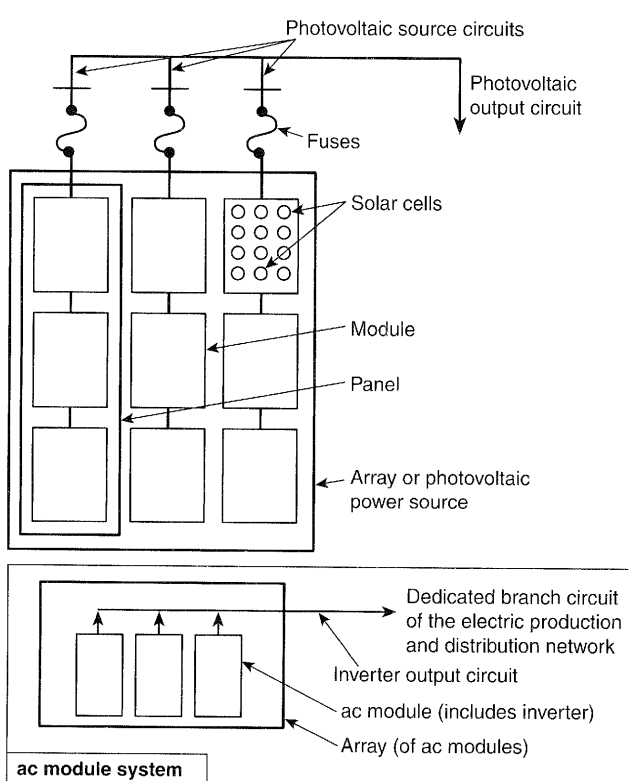
250.4 General Requirements for Grounding and Bonding. The following general requirements identify what grounding and bonding of electrical systems are required to accomplish. The prescriptive methods contained in Article 250 shall be followed to comply with the performance requirements of this section.

ARTICLE 690

Solar Photovoltaic (PV) Systems

I. General

690.1 Scope. The provisions of this article apply to solar PV electrical energy systems, including the array circuit(s), inverter(s), and controller(s) for such systems. [See Figure 690.1(a) and Figure 690.1(b).] Solar PV systems covered by this article may be interactive with other electrical power production sources or stand-alone, with or without electrical energy storage such as batteries. These systems may have ac or dc output for utilization.



Notes:

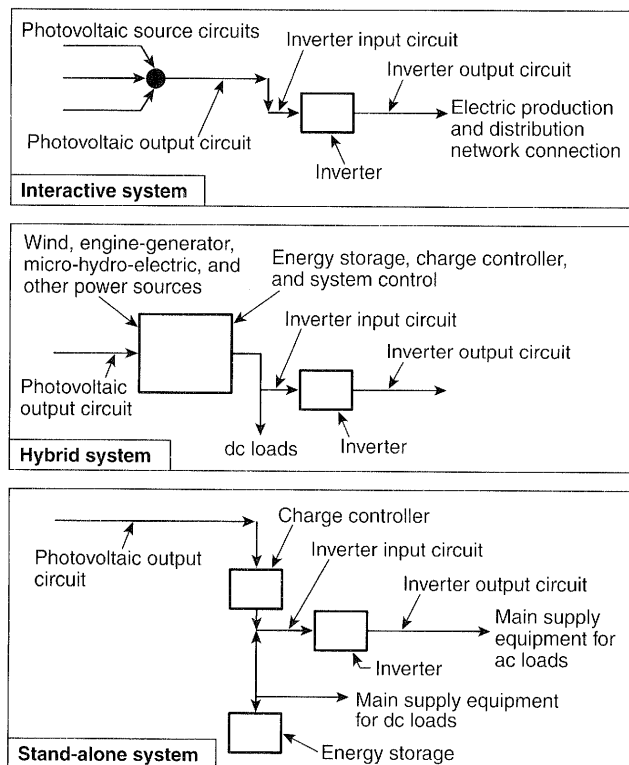
1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means required by Article 690, Part III, are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.

Figure 690.1(a) Identification of Solar Photovoltaic System Components.

690.2 Definitions.

Alternating-Current (ac) Module (Alternating-Current Photovoltaic Module). A complete, environmentally protected unit consisting of solar cells, optics, inverter, and other components, exclusive of tracker, designed to generate ac power when exposed to sunlight.

Array. A mechanically integrated assembly of modules or panels with a support structure and foundation, tracker, and other components, as required, to form a direct-current power-producing unit.



Notes:

1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means and overcurrent protection required by Article 690, Part III, are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.
4. Custom designs occur in each configuration, and some components are optional.

Figure 690.1(b) Identification of Solar Photovoltaic System Components in Common System Configurations.

Bipolar Photovoltaic Array. A PV array that has two outputs, each having opposite polarity to a common reference point or center tap.

Blocking Diode. A diode used to block reverse flow of current into a PV source circuit.

Building Integrated Photovoltaics. Photovoltaic cells, devices, modules, or modular materials that are integrated into the outer surface or structure of a building and serve as the outer protective surface of that building.

DC-to-DC Converter. A device installed in the PV source circuit or PV output circuit that can provide an output dc voltage and current at a higher or lower value than the input dc voltage and current.

Direct-Current (dc) Combiner. A device used in the PV source and PV output circuits to combine two or more dc circuit inputs and provide one dc circuit output.

Diversion Charge Controller. Equipment that regulates the charging process of a battery by diverting power from energy storage to direct-current or alternating-current loads or to an interconnected utility service.

Electrical Production and Distribution Network. A power production, distribution, and utilization system, such as a utility system and connected loads, that is external to and not controlled by the PV power system.

Interactive System. A solar PV system that operates in parallel with and may deliver power to an electrical production and distribution network. For the purpose of this definition, an energy storage subsystem of a solar PV system, such as a battery, is not another electrical production source.

Inverter. Equipment that is used to change voltage level or waveform, or both, of electrical energy. Commonly, an inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a device that changes dc input to an ac output. Inverters may also function as battery chargers that use alternating current from another source and convert it into direct current for charging batteries.

Inverter Input Circuit. Conductors between the inverter and the battery in stand-alone systems or the conductors between the inverter and the PV output circuits for electrical production and distribution network.

Inverter Output Circuit. Conductors between the inverter and an ac panelboard for stand-alone systems or the conductors between the inverter and the service equipment or another electric power production source, such as a utility, for electrical production and distribution network.

Module. A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight.

Monopole Subarray. A PV subarray that has two conductors in the output circuit, one positive (+) and one negative(−). Two monopole PV subarrays are used to form a bipolar PV array.

Multimode Inverter. Equipment having the capabilities of both the utility-interactive inverter and the stand-alone inverter.

Panel. A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.

Photovoltaic Output Circuit. Circuit conductors between the PV source circuit(s) and the inverter or dc utilization equipment.

Photovoltaic Power Source. An array or aggregate of arrays that generates dc power at system voltage and current.

Photovoltaic Source Circuit. Circuits between modules and from modules to the common connection point(s) of the dc system.

Photovoltaic System Voltage. The direct current (dc) voltage of any PV source or PV output circuit. For multiwire installations, the PV system voltage is the highest voltage between any two dc conductors.

Solar Cell. The basic PV device that generates electricity when exposed to light.

Stand-Alone System. A solar PV system that supplies power independently of an electrical production and distribution network.

Subarray. An electrical subset of a PV array.

690.3 Other Articles. Wherever the requirements of other articles of this *Code* and Article 690 differ, the requirements of Article 690 shall apply and, if the system is operated in parallel with a primary source(s) of electricity, the requirements in 705.14, 705.16, 705.32, and 705.143 shall apply.

Exception: Solar PV systems, equipment, or wiring installed in a hazardous (classified) location shall also comply with the applicable portions of Articles 500 through 516.

690.4 General Requirements.

(A) Photovoltaic Systems. Photovoltaic systems shall be permitted to supply a building or other structure in addition to any other electrical supply system(s).

(B) Equipment. Inverters, motor generators, PV modules, PV panels, ac PV modules, dc combiners, dc-to-dc converters, and charge controllers intended for use in PV power systems shall be listed for the PV application.

(C) Qualified Personnel. The installation of equipment and all associated wiring and interconnections shall be performed only by qualified persons.

Informational Note: See Article 100 for the definition of *qualified person*.

(D) Multiple Inverters. A PV system shall be permitted to have multiple inverters installed in or on a single building or structure. Where the inverters are remotely located from each other, a directory in accordance with 705.10 shall be installed at each dc PV system disconnecting means, at each ac disconnecting means, and at the main service dis-

connecting means showing the location of all ac and dc PV system disconnecting means in the building.

Exception: A directory shall not be required where all inverters and PV dc disconnecting means are grouped at the main service disconnecting means.

690.5 Ground-Fault Protection. Grounded dc PV arrays shall be provided with dc ground-fault protection meeting the requirements of 690.5(A) through (C) to reduce fire hazards. Ungrounded dc PV arrays shall comply with 690.35.

Exception: Ground-mounted or pole-mounted PV arrays with not more than two paralleled source circuits and with all dc source and dc output circuits isolated from buildings shall be permitted without ground-fault protection.

(A) Ground-Fault Detection and Interruption. The ground fault protection device or system shall:

- (1) Be capable of detecting a ground fault in the PV array dc current-carrying conductors and components, including any intentionally grounded conductors,
- (2) Interrupt the flow of fault current
- (3) Provide an indication of the fault, and
- (4) Be listed for providing PV ground-fault protection

Automatically opening the grounded conductor for measurement purposes or to interrupt the ground-fault current path shall be permitted. If a grounded conductor is opened to interrupt the ground-fault current path, all conductors of the faulted circuit shall be automatically and simultaneously opened.

Manual operation of the main PV dc disconnect shall not activate the ground-fault protection device or result in grounded conductors becoming ungrounded.

(B) Isolating Faulted Circuits. The faulted circuits shall be isolated by one of the two following methods:

- (1) The ungrounded conductors of the faulted circuit shall be automatically disconnected.
- (2) The inverter or charge controller fed by the faulted circuit shall automatically cease to supply power to output circuits.

(C) Labels and Markings. A warning label shall appear on the utility-interactive inverter or be applied by the installer near the ground-fault indicator at a visible location, stating the following:

WARNING
ELECTRIC SHOCK HAZARD
IF A GROUND FAULT IS INDICATED,
NORMALLY GROUNDED CONDUCTORS MAY
BE UNGROUNDED AND ENERGIZED

When the PV system also has batteries, the same warning shall also be applied by the installer in a visible location at the batteries. The warning sign(s) or label(s) shall comply with 110.21(B).

690.6 Alternating-Current (ac) Modules.

(A) Photovoltaic Source Circuits. The requirements of Article 690 pertaining to PV source circuits shall not apply to ac modules. The PV source circuit, conductors, and inverters shall be considered as internal wiring of an ac module.

(B) Inverter Output Circuit. The output of an ac module shall be considered an inverter output circuit.

(C) Disconnecting Means. A single disconnecting means, in accordance with 690.15 and 690.17, shall be permitted for the combined ac output of one or more ac modules. Additionally, each ac module in a multiple ac module system shall be provided with a connector, bolted, or terminal-type disconnecting means.

(D) Overcurrent Protection. The output circuits of ac modules shall be permitted to have overcurrent protection and conductor sizing in accordance with 240.5(B)(2).

II. Circuit Requirements

690.7 Maximum Voltage.

(A) Maximum Photovoltaic System Voltage. In a dc PV source circuit or output circuit, the maximum PV system voltage for that circuit shall be calculated as the sum of the rated open-circuit voltage of the series-connected PV modules corrected for the lowest expected ambient temperature. For crystalline and multicrystalline silicon modules, the rated open-circuit voltage shall be multiplied by the correction factor provided in Table 690.7. This voltage shall be used to determine the voltage rating of cables, disconnects, overcurrent devices, and other equipment. Where the lowest expected ambient temperature is below -40°C (-40°F), or where other than crystalline or multicrystalline silicon PV modules are used, the system voltage adjustment shall be made in accordance with the manufacturer's instructions.

When open-circuit voltage temperature coefficients are supplied in the instructions for listed PV modules, they shall be used to calculate the maximum PV system voltage as required by 110.3(B) instead of using Table 690.7.

Informational Note: One source for statistically valid, lowest-expected, ambient temperature design data for various locations is the Extreme Annual Mean Minimum Design Dry Bulb Temperature found in the *ASHRAE Handbook — Fundamentals*. These temperature data can be used to calculate maximum voltage using the manufacturer's temperature coefficients relative to the rating temperature of 25°C .

Table 690.7 Voltage Correction Factors for Crystalline and Multicrystalline Silicon Modules

Correction Factors for Ambient Temperatures Below 25°C (77°F). (Multiply the rated open circuit voltage by the appropriate correction factor shown below.)		
Ambient Temperature (°C)	Factor	Ambient Temperature (°F)
24 to 20	1.02	76 to 68
19 to 15	1.04	67 to 59
14 to 10	1.06	58 to 50
9 to 5	1.08	49 to 41
4 to	1.10	40 to 32
-1 to -5	1.12	31 to 23
-6 to -10	1.14	22 to 14
-11 to -15	1.16	13 to 5
-16 to -20	1.18	4 to -4
-21 to -25	1.20	-5 to -13
-26 to -30	1.21	-14 to -22
-31 to -35	1.23	-23 to -31
-36 to -40	1.25	-32 to -40

(B) Direct-Current Utilization Circuits. The voltage of dc utilization circuits shall conform to 210.6.

(C) Photovoltaic Source and Output Circuits. In one- and two-family dwellings, PV source circuits and PV output circuits that do not include lampholders, fixtures, or receptacles shall be permitted to have a maximum PV system voltage up to 600 volts. Other installations with a maximum PV system voltage over 1000 volts shall comply with Article 690, Part IX.

(D) Circuits over 150 Volts to Ground. In one- and two-family dwellings, live parts in PV source circuits and PV output circuits over 150 volts to ground shall not be accessible to other than qualified persons while energized.

Informational Note: See 110.27 for guarding of live parts, and 210.6 for voltage to ground and between conductors.

(E) Bipolar Source and Output Circuits. For 2-wire circuits connected to bipolar systems, the maximum system voltage shall be the highest voltage between the conductors of the 2-wire circuit if all of the following conditions apply:

- (1) One conductor of each circuit of a bipolar subarray is solidly grounded.

Exception: The operation of ground-fault or arc-fault devices (abnormal operation) shall be permitted to interrupt this connection to ground when the entire bipolar array becomes two distinct arrays isolated from each other and the utilization equipment.

- (2) Each circuit is connected to a separate subarray.
- (3) The equipment is clearly marked with a label as follows:

WARNING

BIPOLAR PHOTOVOLTAIC ARRAY.
DISCONNECTION OF NEUTRAL
OR GROUNDED CONDUCTORS
MAY RESULT IN OVERVOLTAGE
ON ARRAY OR INVERTER.

The warning sign(s) or label(s) shall comply with 110.21(B).

(F) Disconnects and Overcurrent Protection. Where energy storage device output conductor length exceeds 1.5 m (5 ft), or where the circuits pass through a wall or partition, the installation shall comply with (1) through (5):

- (1) A disconnecting means and overcurrent protection shall be provided at the energy storage device end of the circuit. Fused disconnecting means or circuit breakers shall be permitted.
- (2) Where fused disconnecting means are used, the line terminals of the disconnecting means shall be connected toward the energy storage device terminals.
- (3) Overcurrent devices or disconnecting means shall not be installed in energy storage device enclosures where explosive atmospheres can exist.
- (4) A second disconnecting means located at the connected equipment shall be installed where the disconnecting means required by (1) is not within sight of the connected equipment.
- (5) Where the energy storage device disconnecting means is not within sight of the PV system ac and dc disconnecting means, placards or directories shall be installed at the locations of all disconnecting means indicating the location of all disconnecting means.

690.8 Circuit Sizing and Current.

(A) Calculation of Maximum Circuit Current. The maximum current for the specific circuit shall be calculated in accordance with 690.8(A)(1) through (A)(5).

Informational Note: Where the requirements of 690.8(A)(1) and (B)(1) are both applied, the resulting multiplication factor is 156 percent.

- (1) **Photovoltaic Source Circuit Currents.** The maximum current shall be the sum of parallel module rated short-circuit currents multiplied by 125 percent.
- (2) **Photovoltaic Output Circuit Currents.** The maximum current shall be the sum of parallel source circuit maximum currents as calculated in 690.8(A)(1).
- (3) **Inverter Output Circuit Current.** The maximum current shall be the inverter continuous output current rating.
- (4) **Stand-Alone Inverter Input Circuit Current.** The maximum current shall be the stand-alone continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

(5) DC-to-DC Converter Output Current. The maximum current shall be the dc-to-dc converter continuous output current rating.

(B) Conductor Ampacity. PV system currents shall be considered to be continuous. Circuit conductors shall be sized to carry not less than the larger of 690.8(B)(1) or (2).

(1) One hundred and twenty-five percent of the maximum currents calculated in 690.8(A) before the application of adjustment and correction factors.

Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

(2) The maximum currents calculated in 690.8(A) after the application of adjustment and correction factors.

(C) Systems with Multiple Direct-Current Voltages. For a PV power source that has multiple output circuit voltages and employs a common-return conductor, the ampacity of the common-return conductor shall not be less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits.

(D) Sizing of Module Interconnection Conductors. Where a single overcurrent device is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall not be less than the sum of the rating of the single overcurrent device plus 125 percent of the short-circuit current from the other parallel-connected modules.

690.9 Overcurrent Protection.

(A) Circuits and Equipment. PV source circuit, PV output circuit, inverter output circuit, and storage battery circuit conductors and equipment shall be protected in accordance with the requirements of Article 240. Protection devices for PV source circuits and PV output circuits shall be in accordance with the requirements of 690.9(B) through (E). Circuits, either ac or dc, connected to current-limited supplies (e.g., PV modules, ac output of utility-interactive inverters), and also connected to sources having significantly higher current availability (e.g., parallel strings of modules, utility power), shall be protected at the source from overcurrent.

Exception: An overcurrent device shall not be required for PV modules or PV source circuit conductors sized in accordance with 690.8(B) where one of the following applies:

(a) There are no external sources such as parallel-connected source circuits, batteries, or backfeed from inverters.

(b) The short-circuit currents from all sources do not exceed the ampacity of the conductors and the maximum overcurrent protective device size rating specified on the PV module nameplate.

(B) Overcurrent Device Ratings. Overcurrent device ratings shall be not less than 125 percent of the maximum currents calculated in 690.8(A).

Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

(C) Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a PV power system shall be listed and shall have the appropriate voltage, current, and interrupt ratings.

(D) Photovoltaic Source and Output Circuits. Listed PV overcurrent devices shall be required to provide overcurrent protection in PV source and output circuits. The overcurrent devices shall be accessible but shall not be required to be readily accessible.

(E) Series Overcurrent Protection. In grounded PV source circuits, a single overcurrent protection device, where required, shall be permitted to protect the PV modules and the interconnecting conductors. In ungrounded PV source circuits complying with 690.35, an overcurrent protection device, where required, shall be installed in each ungrounded circuit conductor and shall be permitted to protect the PV modules and the interconnecting cables.

(F) Power Transformers. Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary.

Exception: A power transformer with a current rating on the side connected toward the utility-interactive inverter output, not less than the rated continuous output current of the inverter, shall be permitted without overcurrent protection from the inverter.

690.10 Stand-Alone Systems. The premises wiring system shall be adequate to meet the requirements of this Code for a similar installation connected to a service. The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of this Code, except as modified by 690.10(A) through (E).

(A) Inverter Output. The ac output from a stand-alone inverter(s) shall be permitted to supply ac power to the building or structure disconnecting means at current levels less than the calculated load connected to that disconnect.

The inverter output rating or the rating of an alternate energy source shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load.

(B) Sizing and Protection. The circuit conductors between the inverter output and the building or structure disconnecting means shall be sized based on the output rating of the inverter. These conductors shall be protected from overcurrents in accordance with Article 240. The overcurrent protection shall be located at the output of the inverter.

(C) Single 120-Volt Supply. The inverter output of a stand-alone solar PV system shall be permitted to supply 120 volts to single-phase, 3-wire, 120/240-volt service equipment or distribution panels where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the rating of the overcurrent device connected to the output of the inverter shall be less than the rating of the neutral bus in the service equipment. This equipment shall be marked with the following words or equivalent:

WARNING

SINGLE 120-VOLT SUPPLY. DO NOT CONNECT
MULTIWIRED BRANCH CIRCUITS!

The warning sign(s) or label(s) shall comply with
110.21(B).

(D) Energy Storage or Backup Power System Requirements. Energy storage or backup power supplies are not required.

(E) Back-Fed Circuit Breakers. Plug-in type back-fed circuit breakers connected to a stand-alone or multimode inverter output in stand-alone systems shall be secured in accordance with 408.36(D). Circuit breakers marked “line” and “load” shall not be back-fed.

690.11 Arc-Fault Circuit Protection (Direct Current). Photovoltaic systems with dc source circuits, dc output circuits, or both, operating at a PV system maximum system voltage of 80 volts or greater, shall be protected by a listed (dc) arc-fault circuit interrupter, PV type, or other system components listed to provide equivalent protection. The PV arc-fault protection means shall comply with the following requirements:

- (1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the dc PV source and dc PV output circuits.
- (2) The system shall require that the disabled or disconnected equipment be manually restarted.
- (3) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.

690.12 Rapid Shutdown of PV Systems on Buildings. PV system circuits installed on or in buildings shall include a rapid shutdown function that controls specific conductors in accordance with 690.12(1) through (5) as follows.

- (1) Requirements for controlled conductors shall apply only to PV system conductors of more than 1.5 m (5 ft) in length inside a building, or more than 3 m (10 ft) from a PV array.
- (2) Controlled conductors shall be limited to not more than 30 volts and 240 volt-amperes within 10 seconds of rapid shutdown initiation.
- (3) Voltage and power shall be measured between any two conductors and between any conductor and ground.
- (4) The rapid shutdown initiation methods shall be labeled in accordance with 690.56(B).
- (5) Equipment that performs the rapid shutdown shall be listed and identified.

III. Disconnecting Means

690.13 Building or Other Structure Supplied by a Photovoltaic System. Means shall be provided to disconnect all ungrounded dc conductors of a PV system from all other conductors in a building or other structure.

(A) Location. The PV disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.

Exception: Installations that comply with 690.31(F) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.

The PV system disconnecting means shall not be installed in bathrooms.

(B) Marking. Each PV system disconnecting means shall be permanently marked to identify it as a PV system disconnect.

(C) Suitable for Use. Each PV system disconnecting means shall not be required to be suitable as service equipment.

(D) Maximum Number of Disconnects. The PV system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure or in a group of separate enclosures.

(E) Grouping. The PV system disconnecting means shall be grouped with other disconnecting means for the system in accordance with 690.13(D). A PV disconnecting means shall not be required at the PV module or array location.

690.15 Disconnection of Photovoltaic Equipment. Means shall be provided to disconnect equipment, such as invert-

ers, batteries, and charge controllers, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified.

A single disconnecting means in accordance with 690.17 shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system.

(A) Utility-Interactive Inverters Mounted in Not Readily Accessible Locations. Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible and shall comply with 690.15(A)(1) through (4):

- (1) A dc PV disconnecting means shall be mounted within sight of or in each inverter.
- (2) An ac disconnecting means shall be mounted within sight of or in each inverter.
- (3) The ac output conductors from the inverter and an additional ac disconnecting means for the inverter shall comply with 690.13(A).
- (4) A plaque shall be installed in accordance with 705.10.

(B) Equipment. Equipment such as PV source circuit isolating switches, overcurrent devices, dc-to-dc converters, and blocking diodes shall be permitted on the PV side of the PV disconnecting means.

(C) Direct-Current Combiner Disconnects. The dc output of dc combiners mounted on roofs of dwellings or other buildings shall have a load break disconnecting means located in the combiner or within 1.8 m (6 ft) of the combiner. The disconnecting means shall be permitted to be remotely controlled but shall be manually operable locally when control power is not available.

(D) Maximum Number of Disconnects. The PV system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure or in a group of separate enclosures.

690.16 Fuses.

(A) Disconnecting Means. Disconnecting means shall be provided to disconnect a fuse from all sources of supply if the fuse is energized from both directions. Such a fuse in a PV source circuit shall be capable of being disconnected independently of fuses in other PV source circuits.

(B) Fuse Servicing. Disconnecting means shall be installed on PV output circuits where overcurrent devices (fuses) must be serviced that cannot be isolated from energized circuits. The disconnecting means shall be within sight of, and accessible to, the location of the fuse or integral with fuse holder and shall comply with 690.17. Where the disconnecting means are located more than 1.8 m (6 ft) from the overcurrent device, a directory showing the loca-

tion of each disconnect shall be installed at the overcurrent device location.

Non-load-break-rated disconnecting means shall be marked "Do not open under load."

690.17 Disconnect Type.

(A) Manually Operable. The disconnecting means for ungrounded PV conductors shall consist of a manually operable switch(es) or circuit breaker(s). The disconnecting means shall be permitted to be power operable with provisions for manual operation in the event of a power-supply failure. The disconnecting means shall be one of the following listed devices:

- (1) A PV industrial control switch marked for use in PV systems
- (2) A PV molded-case circuit breaker marked for use in PV systems
- (3) A PV molded-case switch marked for use in PV systems
- (4) A PV enclosed switch marked for use in PV systems
- (5) A PV open-type switch marked for use in PV systems
- (6) A dc-rated molded-case circuit breaker suitable for backfeed operation
- (7) A dc-rated molded-case switch suitable for backfeed operation
- (8) A dc-rated enclosed switch
- (9) A dc-rated open-type switch
- (10) A dc-rated rated low-voltage power circuit breaker

Informational Note: Devices marked with "line" and "load" are not suitable for backfeed or reverse current.

(B) Simultaneous Opening of Poles. The PV disconnecting means shall simultaneously disconnect all ungrounded supply conductors.

(C) Externally Operable and Indicating. The PV disconnecting means shall be externally operable without exposing the operator to contact with live parts and shall indicate whether in the open or closed position.

(D) Disconnection of Grounded Conductor. A switch, circuit breaker, or other device shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.

Exception No. 1: A switch or circuit breaker that is part of a ground-fault detection system required by 690.5, or that is part of an arc-fault detection/interruption system required by 690.11, shall be permitted to open the grounded conductor when that switch or circuit breaker is automatically opened as a normal function of the device in responding to ground faults.

Exception No. 2: A disconnecting switch shall be permitted in a grounded conductor if all of the following conditions are met:

- (1) *The switch is used only for PV array maintenance.*
- (2) *The switch is accessible only by qualified persons.*
- (3) *The switch is rated for the maximum dc voltage and current that could be present during any operation, including ground-fault conditions.*

(E) Interrupting Rating. The building or structure disconnecting means shall have an interrupting rating sufficient for the maximum circuit voltage and current that is available at the line terminals of the equipment. Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and have the following words or equivalent:

WARNING
ELECTRIC SHOCK HAZARD
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE
AND LOAD SIDES MAY BE ENERGIZED IN THE
OPEN POSITION.

The warning sign(s) or label(s) shall comply with 110.21(B).

Exception: A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for use with specific equipment.

690.18 Installation and Service of an Array. Open circuiting, short circuiting, or opaque covering shall be used to disable an array or portions of an array for installation and service.

Informational Note: Photovoltaic modules are energized while exposed to light. Installation, replacement, or servicing of array components while a module(s) is energized may expose persons to electric shock.

IV. Wiring Methods

690.31 Methods Permitted.

(A) Wiring Systems. All raceway and cable wiring methods included in this *Code*, other wiring systems and fittings specifically listed for use on PV arrays, and wiring as part of a listed system shall be permitted. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement.

Where PV source and output circuits operating at maximum system voltages greater than 30 volts are installed in

readily accessible locations, circuit conductors shall be guarded or installed in a raceway.

Informational Note: Photovoltaic modules operate at elevated temperatures when exposed to high ambient temperatures and to bright sunlight. These temperatures routinely exceed 70°C (158°F) in many locations. Module interconnection conductors are available with insulation rated for wet locations and a temperature rating of 90°C (194°F) or greater.

(B) Identification and Grouping. PV source circuits and PV output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as conductors, feeders, branch circuits of other non-PV systems, or inverter output circuits, unless the conductors of the different systems are separated by a partition. PV system conductors shall be identified and grouped as required by 690.31(B)(1) through (4). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.

(1) PV Source Circuits. PV source circuits shall be identified at all points of termination, connection, and splices.

(2) PV Output and Inverter Circuits. The conductors of PV output circuits and inverter input and output circuits shall be identified at all points of termination, connection, and splices.

(3) Conductors of Multiple Systems. Where the conductors of more than one PV system occupy the same junction box, raceway, or equipment, the conductors of each system shall be identified at all termination, connection, and splice points.

Exception: Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required.

(4) Grouping. Where the conductors of more than one PV system occupy the same junction box or raceway with a removable cover(s), the ac and dc conductors of each system shall be grouped separately by cable ties or similar means at least once and shall then be grouped at intervals not to exceed 1.8 m (6 ft).

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious.

(C) Single-Conductor Cable.

(1) General. Single-conductor cable Type USE-2, and single-conductor cable listed and labeled as photovoltaic (PV) wire shall be permitted in exposed outdoor locations in PV source circuits for PV module interconnections within the PV array.

Exception: Raceways shall be used when required by 690.31(A).

- (2) **Cable Tray.** PV source circuits and PV output circuits using single-conductor cable listed and labeled as photovoltaic (PV) wire of all sizes, with or without a cable tray marking/rating, shall be permitted in cable trays installed in outdoor locations, provided that the cables are supported at intervals not to exceed 300 mm (12 in.) and secured at intervals not to exceed 1.4 m (4.5 ft).

Informational Note: Photovoltaic wire and PV cable have a nonstandard outer diameter. See Table 1 of Chapter 9 for conduit fill calculations.

(D) Multiconductor Cable. Multiconductor cable Type TC-ER or Type USE-2 shall be permitted in outdoor locations in PV inverter output circuits where used with utility-interactive inverters mounted in locations that are not readily accessible. The cable shall be secured at intervals not exceeding 1.8 m (6 ft). Equipment grounding for the utilization equipment shall be provided by an equipment grounding conductor within the cable.

(E) Flexible Cords and Cables. Flexible cords and cables, where used to connect the moving parts of tracking PV modules, shall comply with Article 400 and shall be of a type identified as a hard service cord or portable power cable; they shall be suitable for extra-hard usage, listed for outdoor use, water resistant, and sunlight resistant. Allowable ampacities shall be in accordance with 400.5. For ambient temperatures exceeding 30°C (86°F), the ampacities shall be derated by the appropriate factors given in Table 690.31(E).

(F) Small-Conductor Cables. Single-conductor cables listed for outdoor use that are sunlight resistant and moisture resistant in sizes 16 AWG and 18 AWG shall be permitted for module interconnections where such cables meet the ampacity requirements of 400.5. Section 310.15 shall be used to determine the cable ampacity adjustment and correction factors.

(G) Direct-Current Photovoltaic Source and Direct-Current Output Circuits on or Inside a Building. Where dc PV source or dc PV output circuits from building-integrated systems or other PV systems are run inside a building or structure, they shall be contained in metal raceways, Type MC metal-clad cable that complies with 250.118(10), or metal enclosures from the point of penetration of the surface of the building or structure to the first readily accessible disconnecting means. The disconnecting means shall comply with 690.13(B) and (C) and 690.15(A) and (B). The wiring methods shall comply with the additional installation requirements in 690.31(G)(1) through (4).

(1) Embedded in Building Surfaces. Where circuits are embedded in built-up, laminate, or membrane roofing materials in roof areas not covered by PV modules and associated equipment, the location of circuits shall be clearly marked using a marking protocol that is approved as being suitable for continuous exposure to sunlight and weather.

(2) Flexible Wiring Methods. Where flexible metal conduit (FMC) smaller than metric designator 21 (trade size $\frac{3}{4}$) or Type MC cable smaller than 25 mm (1 in.) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 1.8 m (6 ft) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means.

(3) Marking and Labeling Required. The following wiring methods and enclosures that contain PV power source conductors shall be marked with the wording WARNING: PHOTOVOLTAIC POWER SOURCE by means of permanently affixed labels or other approved permanent marking:

- (1) Exposed raceways, cable trays, and other wiring methods
- (2) Covers or enclosures of pull boxes and junction boxes
- (3) Conduit bodies in which any of the available conduit openings are unused

Table 690.31(E) Correction Factors

Ambient Temperature (°C)	Temperature Rating of Conductor				Ambient Temperature (°F)
	60°C (140°F)	75°C (167°F)	90°C (194°F)	105°C (221°F)	
30	1.00	1.00	1.00	1.00	86
31–35	0.91	0.94	0.96	0.97	87–95
36–40	0.82	0.88	0.91	0.93	96–104
41–45	0.71	0.82	0.87	0.89	105–113
46–50	0.58	0.75	0.82	0.86	114–122
51–55	0.41	0.67	0.76	0.82	123–131
56–60	—	0.58	0.71	0.77	132–140
61–70	—	0.33	0.58	0.68	141–158
71–80	—	—	0.41	0.58	159–176

(4) Marking and Labeling Methods and Locations. The labels or markings shall be visible after installation. The labels shall be reflective, and all letters shall be capitalized and shall be a minimum height of 9.5 mm ($\frac{3}{8}$ in.) in white on a red background. PV power circuit labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 3 m (10 ft). Labels required by this section shall be suitable for the environment where they are installed.

(H) Flexible, Fine-Stranded Cables. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14.

(I) Bipolar Photovoltaic Systems. Where the sum, without consideration of polarity, of the PV system voltages of the two monopole subarrays exceeds the rating of the conductors and connected equipment, monopole subarrays in a bipolar PV system shall be physically separated, and the electrical output circuits from each monopole subarray shall be installed in separate raceways until connected to the inverter. The disconnecting means and overcurrent protective devices for each monopole subarray output shall be in separate enclosures. All conductors from each separate monopole subarray shall be routed in the same raceway. Bipolar PV systems shall be clearly marked with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) may result in overvoltage on the equipment.

Exception: Listed switchgear rated for the maximum voltage between circuits and containing a physical barrier separating the disconnecting means for each monopole subarray shall be permitted to be used instead of disconnecting means in separate enclosures.

(J) Module Connection Arrangement. The connection to a module or panel shall be arranged so that removal of a module or panel from a PV source circuit does not interrupt a grounded conductor connection to other PV source circuits.

690.32 Component Interconnections. Fittings and connectors that are intended to be concealed at the time of on-site assembly, where listed for such use, shall be permitted for on-site interconnection of modules or other array components. Such fittings and connectors shall be equal to the wiring method employed in insulation, temperature rise, and fault-current withstand, and shall be capable of resisting the effects of the environment in which they are used.

690.33 Connectors. The connectors permitted by Article 690 shall comply with 690.33(A) through (E).

(A) Configuration. The connectors shall be polarized and shall have a configuration that is noninterchangeable with receptacles in other electrical systems on the premises.

(B) Guarding. The connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.

(C) Type. The connectors shall be of the latching or locking type. Connectors that are readily accessible and that are used in circuits operating at over 30 volts, nominal, maximum system voltage for dc circuits, or 30 volts for ac circuits, shall require a tool for opening.

(D) Grounding Member. The grounding member shall be the first to make and the last to break contact with the mating connector.

(E) Interruption of Circuit. Connectors shall be either (1) or (2):

- (1) Be rated for interrupting current without hazard to the operator.
- (2) Be a type that requires the use of a tool to open and marked "Do Not Disconnect Under Load" or "Not for Current Interrupting."

690.34 Access to Boxes. Junction, pull, and outlet boxes located behind modules or panels shall be so installed that the wiring contained in them can be rendered accessible directly or by displacement of a module(s) or panel(s) secured by removable fasteners and connected by a flexible wiring system.

690.35 Ungrounded Photovoltaic Power Systems. Photovoltaic power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G).

(A) Disconnects. All PV source and output circuit conductors shall have disconnects complying with 690, Part III.

(B) Overcurrent Protection. All PV source and output circuit conductors shall have overcurrent protection complying with 690.9.

(C) Ground-Fault Protection. All PV source and output circuits shall be provided with a ground-fault protection device or system that complies with 690.35(1) through (4):

- (1) Detects ground fault(s) in the PV array dc current-carrying conductors and components
- (2) Indicates that a ground fault has occurred
- (3) Automatically disconnects all conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to output circuits
- (4) Is listed for providing PV ground-fault protection

(D) Conductors. The PV source conductors shall consist of the following:

- (1) Metallic or nonmetallic jacketed multiconductor cables
- (2) Conductors installed in raceways
- (3) Conductors listed and identified as PV wire installed as exposed, single conductors, or
- (4) Conductors that are direct-buried and identified for direct-burial use

(E) Battery Systems. The PV power system direct-current circuits shall be permitted to be used with ungrounded battery systems complying with 690.71(G).

(F) Marking. The PV power source shall be labeled with the following warning at each junction box, combiner box, disconnect, and device where energized, ungrounded circuits may be exposed during service:

WARNING

ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED.

The warning sign(s) or label(s) shall comply with 110.21(B).

(G) Equipment. The inverters or charge controllers used in systems with ungrounded PV source and output circuits shall be listed for the purpose.

V. Grounding

690.41 System Grounding. Photovoltaic systems shall comply with one of the following:

- (1) Ungrounded systems shall comply with 690.35.
- (2) Grounded two-wire systems shall have one conductor grounded or be impedance grounded, and the system shall comply with 690.5.
- (3) Grounded bipolar systems shall have the reference (center tap) conductor grounded or be impedance grounded, and the system shall comply with 690.5.
- (4) Other methods that accomplish equivalent system protection in accordance with 250.4(A) with equipment listed and identified for the use shall be permitted to be used.

690.42 Point of System Grounding Connection. The dc circuit grounding connection shall be made at any single point on the PV output circuit.

Informational Note: Locating the grounding connection point as close as practicable to the PV source better protects the system from voltage surges due to lightning.

Exception: Systems with a 690.5 ground-fault protection device shall be permitted to have the required grounded

conductor-to-ground bond made by the ground-fault protection device. This bond, where internal to the ground-fault equipment, shall not be duplicated with an external connection.

690.43 Equipment Grounding. Equipment grounding conductors and devices shall comply with 690.43(A) through (F).

(A) Equipment Grounding Required. Exposed non-current-carrying metal parts of PV module frames, electrical equipment, and conductor enclosures shall be grounded in accordance with 250.134 or 250.136(A), regardless of voltage.

(B) Equipment Grounding Conductor Required. An equipment grounding conductor between a PV array and other equipment shall be required in accordance with 250.110.

(C) Structure as Equipment Grounding Conductor. Devices listed and identified for grounding the metallic frames of PV modules or other equipment shall be permitted to bond the exposed metal surfaces or other equipment to mounting structures. Metallic mounting structures, other than building steel, used for grounding purposes shall be identified as equipment-grounding conductors or shall have identified bonding jumpers or devices connected between the separate metallic sections and shall be bonded to the grounding system.

(D) Photovoltaic Mounting Systems and Devices. Devices and systems used for mounting PV modules that are also used to provide grounding of the module frames shall be identified for the purpose of grounding PV modules.

(E) Adjacent Modules. Devices identified and listed for bonding the metallic frames of PV modules shall be permitted to bond the exposed metallic frames of PV modules to the metallic frames of adjacent PV modules.

(F) All Conductors Together. Equipment grounding conductors for the PV array and structure (where installed) shall be contained within the same raceway or cable or otherwise run with the PV array circuit conductors when those circuit conductors leave the vicinity of the PV array.

690.45 Size of Equipment Grounding Conductors. Equipment grounding conductors for PV source and PV output circuits shall be sized in accordance with 250.122. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated at the PV maximum circuit current shall be used when applying Table 250.122. Increases in equipment grounding conductor size to address voltage drop considerations shall not be required. An equipment grounding conductor shall not be smaller than 14 AWG.

690.46 Array Equipment Grounding Conductors. For PV modules, equipment grounding conductors smaller than 6 AWG shall comply with 250.120(C).

Where installed in raceways, equipment grounding conductors and grounding electrode conductors not larger than 6 AWG shall be permitted to be solid.

690.47 Grounding Electrode System.

(A) Alternating-Current Systems. If installing an ac system, a grounding electrode system shall be provided in accordance with 250.50 through 250.60. The grounding electrode conductor shall be installed in accordance with 250.64.

(B) Direct-Current Systems. If installing a dc system, a grounding electrode system shall be provided in accordance with 250.166 for grounded systems or 250.169 for ungrounded systems. The grounding electrode conductor shall be installed in accordance with 250.64.

A common dc grounding-electrode conductor shall be permitted to serve multiple inverters. The size of the common grounding electrode and the tap conductors shall be in accordance with 250.166. The tap conductors shall be connected to the common grounding-electrode conductor by exothermic welding or with connectors listed as grounding and bonding equipment in such a manner that the common grounding electrode conductor remains without a splice or joint.

An ac equipment grounding system shall be permitted to be used for equipment grounding of inverters and other equipment and for the ground-fault detection reference for ungrounded PV systems.

(C) Systems with Alternating-Current and Direct-Current Grounding Requirements. Photovoltaic systems having dc circuits and ac circuits with no direct connection between the dc grounded conductor and ac grounded conductor shall have a dc grounding system. The dc grounding system shall be bonded to the ac grounding system by one of the methods in (1), (2), or (3).

This section shall not apply to ac PV modules.

When using the methods of (C)(2) or (C)(3), the existing ac grounding electrode system shall meet the applicable requirements of Article 250, Part III.

Informational Note No. 1: ANSI/UL 1741, *Standard for Inverters, Converters, and Controllers for Use in Independent Power Systems*, requires that any inverter or charge controller that has a bonding jumper between the grounded dc conductor and the grounding system connection point have that point marked as a grounding electrode conductor (GEC) connection point. In PV inverters, the terminals for the dc equipment grounding conductors and the terminals for ac equipment grounding conductors are generally connected to, or electrically in common with, a grounding busbar that has a marked dc GEC terminal.

Informational Note No. 2: For utility-interactive systems, the existing premises grounding system serves as the ac grounding system.

(1) Separate Direct-Current Grounding Electrode System Bonded to the Alternating-Current Grounding Electrode System. A separate dc grounding electrode or system shall be installed, and it shall be bonded directly to the ac grounding electrode system. The size of any bonding jumper(s) between the ac and dc systems shall be based on the larger size of the existing ac grounding electrode conductor or the size of the dc grounding electrode conductor specified by 250.166. The dc grounding electrode system conductor(s) or the bonding jumpers to the ac grounding electrode system shall not be used as a substitute for any required ac equipment grounding conductors.

(2) Common Direct-Current and Alternating-Current Grounding Electrode. A dc grounding electrode conductor of the size specified by 250.166 shall be run from the marked dc grounding electrode connection point to the ac grounding electrode. Where an ac grounding electrode is not accessible, the dc grounding electrode conductor shall be connected to the ac grounding electrode conductor in accordance with 250.64(C)(1) or 250.64(C)(C)(2) or by using a connector listed for grounding and bonding. This dc grounding electrode conductor shall not be used as a substitute for any required ac equipment grounding conductors.

(3) Combined Direct-Current Grounding Electrode Conductor and Alternating-Current Equipment Grounding Conductor. An unspliced, or irreversibly spliced, combined grounding conductor shall be run from the marked dc grounding electrode conductor connection point along with the ac circuit conductors to the grounding busbar in the associated ac equipment. This combined grounding conductor shall be the larger of the sizes specified by 250.122 or 250.166 and shall be installed in accordance with 250.64(E). For ungrounded systems, this conductor shall be sized in accordance with 250.122 and shall not be required to be larger than the largest ungrounded phase conductor.

(D) Additional Auxiliary Electrodes for Array Grounding. A grounding electrode shall be installed in accordance with 250.52 and 250.54 at the location of all ground- and pole-mounted PV arrays and as close as practicable to the location of roof-mounted PV arrays. The electrodes shall be connected directly to the array frame(s) or structure. The dc grounding electrode conductor shall be sized according to 250.166. Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements. The structure of a ground- or pole-mounted PV array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. Roof-mounted PV arrays shall be permitted to use

the metal frame of a building or structure if the requirements of 250.52(A)(2) are met.

Exception No. 1: An array grounding electrode(s) shall not be required where the load served by the array is integral with the array.

Exception No. 2: An additional array grounding electrode(s) shall not be required if located within 1.8 m (6 ft) of the premises wiring electrode.

690.48 Continuity of Equipment Grounding Systems.

Where the removal of equipment disconnects the bonding connection between the grounding electrode conductor and exposed conducting surfaces in the PV source or output circuit equipment, a bonding jumper shall be installed while the equipment is removed.

690.49 Continuity of Photovoltaic Source and Output Circuit Grounded Conductors.

Where the removal of the utility-interactive inverter or other equipment disconnects the bonding connection between the grounding electrode conductor and the PV source and/or PV output circuit grounded conductor, a bonding jumper shall be installed to maintain the system grounding while the inverter or other equipment is removed.

690.50 Equipment Bonding Jumpers. Equipment bonding jumpers, if used, shall comply with 250.120(C).

VI. Marking

690.51 Modules. Modules shall be marked with identification of terminals or leads as to polarity, maximum overcurrent device rating for module protection, and with the following ratings:

- (1) Open-circuit voltage
- (2) Operating voltage
- (3) Maximum permissible system voltage
- (4) Operating current
- (5) Short-circuit current
- (6) Maximum power

690.52 Alternating-Current Photovoltaic Modules.

Alternating-current modules shall be marked with identification of terminals or leads and with identification of the following ratings:

- (1) Nominal operating ac voltage
- (2) Nominal operating ac frequency
- (3) Maximum ac power
- (4) Maximum ac current
- (5) Maximum overcurrent device rating for ac module protection

690.53 Direct-Current Photovoltaic Power Source. A permanent label for the direct-current PV power source indicating the information specified in (1) through (5) shall be provided by the installer at the PV disconnecting means:

- (1) Rated maximum power-point current.
- (2) Rated maximum power-point voltage.
- (3) Maximum system voltage.

Informational Note to (3): See 690.7(A) for maximum PV system voltage.

- (4) Maximum circuit current. Where the PV power source has multiple outputs, 690.53(1) and (4) shall be specified for each output.

Informational Note to (4): See 690.8(A) for calculation of maximum circuit current.

- (5) Maximum rated output current of the charge controller (if installed).

Informational Note: Reflecting systems used for irradiance enhancement may result in increased levels of output current and power.

690.54 Interactive System Point of Interconnection. All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated ac output current and the nominal operating ac voltage.

690.55 Photovoltaic Power Systems Employing Energy Storage.

Photovoltaic power systems employing energy storage shall also be marked with the maximum operating voltage, including any equalization voltage and the polarity of the grounded circuit conductor.

690.56 Identification of Power Sources.

(A) Facilities with Stand-Alone Systems. Any structure or building with a PV power system that is not connected to a utility service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location acceptable to the authority having jurisdiction. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system. The marking shall be in accordance with 690.31(E).

(B) Facilities with Utility Services and PV Systems. Buildings or structures with both utility service and a PV system shall have a permanent plaque or directory providing the location of the service disconnecting means and the PV system disconnecting means if not located at the same

location. The warning sign(s) or label(s) shall comply with 110.21(B).

(C) Facilities with Rapid Shutdown. Buildings or structures with both utility service and a PV system, complying with 690.12, shall have a permanent plaque or directory including the following wording:

PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN

The plaque or directory shall be reflective, with all letters capitalized and having a minimum height of 9.5 mm ($\frac{3}{8}$ in.), in white on red background.

VII. Connection to Other Sources

690.57 Load Disconnect. A load disconnect that has multiple sources of power shall disconnect all sources when in the off position.

690.60 Identified Interactive Equipment. Only inverters and ac modules listed and identified as interactive shall be permitted in interactive systems.

690.61 Loss of Interactive System Power. An inverter or an ac module in an interactive solar PV system shall automatically de-energize its output to the connected electrical production and distribution network upon loss of voltage in that system and shall remain in that state until the electrical production and distribution network voltage has been restored.

A normally interactive solar PV system shall be permitted to operate as a stand-alone system to supply loads that have been disconnected from electrical production and distribution network sources.

690.63 Unbalanced Interconnections. Unbalanced connections shall be in accordance with 705.100.

690.64 Point of Connection. Point of connection shall be in accordance with 705.12.

VIII. Storage Batteries

690.71 Installation.

(A) General. Storage batteries in a solar photovoltaic system shall be installed in accordance with the provisions of Article 480. The interconnected battery cells shall be considered grounded where the photovoltaic power source is installed in accordance with 690.41.

(B) Dwellings.

(1) Operating Voltage. Storage batteries for dwellings shall have the cells connected so as to operate at a voltage of 50 volts, nominal, or less.

Exception: Where live parts are not accessible during routine battery maintenance, a battery system voltage in accordance with 690.7 shall be permitted.

(2) Guarding of Live Parts. Live parts of battery systems for dwellings shall be guarded to prevent accidental contact by persons or objects, regardless of voltage or battery type.

Informational Note: Batteries in solar photovoltaic systems are subject to extensive charge-discharge cycles and typically require frequent maintenance, such as checking electrolyte and cleaning connections.

(C) Current Limiting. A listed, current-limiting, overcurrent device shall be installed in each circuit adjacent to the batteries where the available short-circuit current from a battery or battery bank exceeds the interrupting or withstand ratings of other equipment in that circuit. The installation of current-limiting fuses shall comply with 690.16.

(D) Battery Nonconductive Cases and Conductive Racks. Flooded, vented, lead-acid batteries with more than twenty-four 2-volt cells connected in series (48 volts, nominal) shall not use conductive cases or shall not be installed in conductive cases. Conductive racks used to support the nonconductive cases shall be permitted where no rack material is located within 150 mm (6 in.) of the tops of the nonconductive cases.

This requirement shall not apply to any type of valve-regulated lead-acid (VRLA) battery or any other types of sealed batteries that may require steel cases for proper operation.

(E) Disconnection of Series Battery Circuits. Battery circuits subject to field servicing, where more than twenty-four 2-volt cells are connected in series (48 volts, nominal), shall have provisions to disconnect the series-connected strings into segments of 24 cells or less for maintenance by qualified persons. Non-load-break bolted or plug-in disconnects shall be permitted.

(F) Battery Maintenance Disconnecting Means. Battery installations, where there are more than twenty-four 2-volt cells connected in series (48 volts, nominal), shall have a disconnecting means, accessible only to qualified persons, that disconnects the grounded circuit conductor(s) in the battery electrical system for maintenance. This disconnecting means shall not disconnect the grounded circuit conductor(s) for the remainder of the photovoltaic electrical system. A non-load-break-rated switch shall be permitted to be used as the disconnecting means.

(G) Battery Systems of More Than 48 Volts. On photovoltaic systems where the battery system consists of more than twenty-four 2-volt cells connected in series (more than 48 volts, nominal), the battery system shall be permitted to

operate with ungrounded conductors, provided the following conditions are met:

- (1) The photovoltaic array source and output circuits shall comply with 690.41.
- (2) The dc and ac load circuits shall be solidly grounded.
- (3) All main ungrounded battery input/output circuit conductors shall be provided with switched disconnects and overcurrent protection.
- (4) A ground-fault detector and indicator shall be installed to monitor for ground faults in the battery bank.

(H) Disconnects and Overcurrent Protection. Where energy storage device input and output terminals are more than 1.5 m (5 ft) from connected equipment, or where the circuits from these terminals pass through a wall or partition, the installation shall comply with the following:

- (1) A disconnecting means and overcurrent protection shall be provided at the energy storage device end of the circuit. Fused disconnecting means or circuit breakers shall be permitted to be used.
- (2) Where fused disconnecting means are used, the line terminals of the disconnecting means shall be connected toward the energy storage device terminals.
- (3) Overcurrent devices or disconnecting means shall not be installed in energy storage device enclosures where explosive atmospheres can exist.
- (4) A second disconnecting means located at the connected equipment shall be installed where the disconnecting means required by 690.71(H)(1) is not within sight of the connected equipment.
- (5) Where the energy storage device disconnecting means is not within sight of the PV system ac and dc disconnecting means, placards or directories shall be installed at the locations of all disconnecting means indicating the location of all disconnecting means.

690.72 Charge Control.

(A) General. Equipment shall be provided to control the charging process of the battery. Charge control shall not be required where the design of the photovoltaic source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells and the maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer.

All adjusting means for control of the charging process shall be accessible only to qualified persons.

Informational Note: Certain battery types such as valve-regulated lead acid or nickel cadmium can experience thermal failure when overcharged.

(B) Diversion Charge Controller.

(1) Sole Means of Regulating Charging. A photovoltaic power system employing a diversion charge controller as the sole means of regulating the charging of a battery shall be equipped with a second independent means to prevent overcharging of the battery.

(2) Circuits with Direct-Current Diversion Charge Controller and Diversion Load. Circuits containing a dc diversion charge controller and a dc diversion load shall comply with the following:

- (1) The current rating of the diversion load shall be less than or equal to the current rating of the diversion load charge controller. The voltage rating of the diversion load shall be greater than the maximum battery voltage. The power rating of the diversion load shall be at least 150 percent of the power rating of the photovoltaic array.
- (2) The conductor ampacity and the rating of the overcurrent device for this circuit shall be at least 150 percent of the maximum current rating of the diversion charge controller.

(3) PV Systems Using Utility-Interactive Inverters. Photovoltaic power systems using utility-interactive inverters to control battery state-of-charge by diverting excess power into the utility system shall comply with (1) and (2):

- (1) These systems shall not be required to comply with 690.72(B)(2). The charge regulation circuits used shall comply with the requirements of 400.5.
- (2) These systems shall have a second, independent means of controlling the battery charging process for use when the utility is not present or when the primary charge controller fails or is disabled.

(C) Buck/Boost Direct-Current Converters. When buck/boost charge controllers and other dc power converters that increase or decrease the output current or output voltage with respect to the input current or input voltage are installed, the requirements shall comply with 690.72(C)(1) and (C)(2).

- (1) The ampacity of the conductors in output circuits shall be based on the maximum rated continuous output current of the charge controller or converter for the selected output voltage range.
- (2) The voltage rating of the output circuits shall be based on the maximum voltage output of the charge controller or converter for the selected output voltage range.

690.74 Battery Interconnections.

(A) Flexible Cables. Flexible cables, as identified in Article 400, in sizes 2/0 AWG and larger shall be permitted within the battery enclosure from battery terminals to a nearby junction box where they shall be connected to an approved wiring method. Flexible battery cables shall also

be permitted between batteries and cells within the battery enclosure. Such cables shall be listed for hard-service use and identified as moisture resistant.

Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14.

IX. Systems over 1000 Volts

690.80 General. Solar PV systems with a maximum system voltage over 1000 volts dc shall comply with Article 490 and other requirements applicable to installations rated over 1000 volts.

690.81 Listing. Products listed for PV systems shall be permitted to be used and installed in accordance with their listing. PV wire that is listed for direct burial at voltages above 600 volts, but not exceeding 2000 volts, shall be installed in accordance with Table 300.50, column 1.

690.85 Definitions. For the purposes of Part VIII of this article, the voltages used to determine cable and equipment ratings are as follows.

Battery Circuits. In battery circuits, the highest voltage experienced under charging or equalizing conditions.

Photovoltaic Circuits. In dc PV source circuits and PV output circuits, the maximum system voltage.

X. Electric Vehicle Charging

690.90 General. Photovoltaic systems used directly to charge electric vehicles shall comply with Article 625 in addition to the requirements of this article.

690.91 Charging Equipment. Electric vehicle couplers shall comply with 625.10. Personnel protection systems in accordance with 625.22 and automatic de-energization of cables in accordance with 625.19 are not required for PV systems with maximum system voltages of less than 80 volts dc.

ARTICLE 692 Fuel Cell Systems

I. General

692.1 Scope. This article identifies the requirements for the installation of fuel cell power systems, which may be stand-alone or interactive with other electric power production sources and may be with or without electric energy

storage such as batteries. These systems may have ac or dc output for utilization.

692.2 Definitions.

Fuel Cell. An electrochemical system that consumes fuel to produce an electric current. In such cells, the main chemical reaction used for producing electric power is not combustion. However, there may be sources of combustion used within the overall cell system, such as reformers/fuel processors.

Fuel Cell System. The complete aggregate of equipment used to convert chemical fuel into usable electricity and typically consisting of a reformer, stack, power inverter, and auxiliary equipment.

Interactive System. A fuel cell system that operates in parallel with and may deliver power to an electrical production and distribution network. For the purpose of this definition, an energy storage subsystem of a fuel cell system, such as a battery, is not another electrical production source.

Maximum System Voltage. The highest fuel cell inverter output voltage between any ungrounded conductors present at accessible output terminals.

Output Circuit. The conductors used to connect the fuel cell system to its electrical point of delivery.

Informational Note: In the case of sites that have series- or parallel-connected multiple units, the term *output circuit* also refers to the conductors used to electrically interconnect the fuel cell system(s).

Point of Common Coupling. The point at which the power production and distribution network and the customer interface occurs in an interactive system. Typically, this is the load side of the power network meter.

Stand-Alone System. A fuel cell system that supplies power independently of an electrical production and distribution network.

692.3 Other Articles. Wherever the requirements of other articles of this Code and Article 692 differ, the requirements of Article 692 shall apply, and, if the system is operated in parallel with a primary source(s) of electricity, the requirements in 705.14, 705.16, 705.32, and 705.143 shall apply.

692.4 Installation.

(A) Fuel Cell System. A fuel cell system shall be permitted to supply a building or other structure in addition to any service(s) of another electricity supply system(s).

(B) Identification. A permanent plaque or directory, denoting all electric power sources on or in the premises, shall be installed at each service equipment location.

Informative Annex A Product Safety Standards

Informative Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only.

This informative annex provides a list of product safety standards used for product listing where that listing is required by this *Code*. It is recognized that this list is current at the time of publication but that new standards or modi-

fications to existing standards can occur at any time while this edition of the *Code* is in effect.

This informative annex does not form a mandatory part of the requirements of this *Code* but is intended only to provide *Code* users with informational guidance about the product characteristics about which *Code* requirements have been based.

Product Standard Name	Product Standard Number
Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings	UL 2515
Antenna-Discharge Units	UL 452
Arc-Fault Circuit-Interrupters	UL 1699
Armored Cable	UL 4
Attachment Plugs and Receptacles	UL 498
Audio, Video and Similar Electronic Apparatus — Safety Requirements	UL 60065
Audio/Video, Information and Communication Technology Equipment — Part 1: Safety Requirements	UL 62368-1
Batteries for Use in Electric Vehicles	UL 2580
Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications	Subject 1973
Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings	UL 2420
Busways	UL 857
Cables — Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables	UL 493
Cables — Thermoplastic-Insulated Wires and Cables	UL 83
Cables — Thermoset-Insulated Wires and Cables	UL 44
Cable and Cable Fittings for Use in Hazardous (Classified) Locations	UL 2225
Cables for Non-Power-Limited Fire-Alarm Circuits	UL 1425
Cables for Power-Limited Fire-Alarm Circuits	UL 1424
Capacitors	UL 810
Cellular Metal Floor Raceways and Fittings	UL 209
Circuit Breakers for Use in Communication Equipment	UL 489A
Circuit Integrity (CI) Cable — Fire Tests for Electrical Circuit Protective Systems	Subject 1724
Circuit Integrity (CI) Cable — Tests for Fire Resistive Cables	UL 2196
Class 2 Power Units	UL 1310
Communication Circuit Accessories	UL 1863
Communications Cables	UL 444
Community-Antenna Television Cables	UL 1655
Concentrator Photovoltaic Modules and Assemblies	Subject 8703
Conduit, Tubing, and Cable Fittings	UL 514B
• Connectors for Use in Photovoltaic Systems	Subject 6703
Cord Sets and Power-Supply Cords	UL 817
Cover Plates for Flush-Mounted Wiring Devices	UL 514D
Data-Processing Cable	UL 1690
Distributed Wiring Harnesses	Subject 9703
Electric Generators	UL 1004-4
Electric Heating Appliances	UL 499
Electric Sign Components	UL 879
Electric Signs	UL 48
Electric Spas, Equipment Assemblies, and Associated Equipment	UL 1563
Electric Vehicle (EV) Charging System Equipment	UL 2202
Electric Vehicle Supply Equipment	UL 2594
• Electric Water Heaters for Pools and Tubs	UL 1261
Electrical Apparatus for Explosive Gas Atmospheres — Part 15: Type of Protection “n”	ANSI/ISA-60079-15/ANSI/UL 60079-15
Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations Type of Protection — Encapsulation “m”	ANSI/ISA-60079-18/ANSI/UL 60079-18
Electrical Apparatus for Use in Zone 20, Zone 21, and Zone 22 Hazardous (Classified) Locations — Protection by Encapsulation “mD”	ANSI/ISA-61241-18
Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations — Protection by Enclosure “tD”	ANSI/ISA-61241-1
Electrical Apparatus for Use in Zone 20, Zone 21, and Zone 22 Hazardous (Classified) Locations — General Requirements	ANSI/ISA-61241-0
Electrical Apparatus for Use in Zone 20, Zone 21, and Zone 22 Hazardous (Classified) Locations — Protection by Intrinsic Safety “iD”	ANSI/ISA-61241-11
Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations — Protection by Pressurization “pD”	ANSI/ISA-61241-2
• Electrical Intermediate Metal Conduit — Steel	UL 1242
Electrical Metallic Tubing — Aluminum	UL 797A
Electrical Metallic Tubing — Steel	UL 797
Electrical Nonmetallic Tubing	UL 1653
Electrical Resistance Heat Tracing for Industrial Applications	IEEE 515

Product Standard Name	Product Standard Number
Electrical Rigid Metal Conduit — Steel	UL 6
Electric-Battery-Powered Industrial Trucks	UL 583
Electrochemical Capacitors	UL 810A
• Emergency Lighting and Power Equipment	UL 924
Enclosed and Dead-Front Switches	UL 98
Enclosed and Dead-Front Switches for Use in Photovoltaic Systems	Subject 98B
Enclosures for Electrical Equipment	UL 50
Enclosures for Electrical Equipment, Environmental Considerations	UL 50E
Energy Management Equipment	UL 916
Explosionproof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations	UL 1203
Explosive Gas Atmospheres — Part 0: Equipment- General requirements	ANSI/ISA-60079-0/ANSI/UL 60079-0
Explosive Gas Atmospheres — Part 7: Increased safety “e”	ANSI/ISA-60079-7/ANSI/UL 60079-7
Explosive Gas Atmospheres — Part 1: Type of protection – Flameproof “d”	ANSI/ISA-60079-1/ANSI/UL 60079-1
Explosive Gas Atmospheres — Part 5: Type of protection – Powder filling “q”	ANSI/ISA-60079-5/ANSI/UL 60079-5
Explosive Gas Atmospheres — Part 6: Type of protection – Oil immersion “o”	ANSI/ISA-60079-6/ANSI/UL 60079-6
Fire Pump Controllers	UL 218
Fire Pump Motors	UL 1004-5
Fire Resistive Cables, Test for	UL 2196
Fixture Wire	UL 66
Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts, Test for	UL 1666
Flat-Plate Photovoltaic Modules and Panels	UL 1703
Flexible Cords and Cables	UL 62
Flexible Lighting Products	UL 2388
Flexible Metal Conduit	UL 1
Fluorescent-Lamp Ballasts	UL 935
Gas and Vapor Detectors and Sensors	UL 2075
Gas-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles	UL 307B
Gas-Fired Cooking Appliances for Recreational Vehicles	UL 1075
Gas-Tube-Sign Cable	UL 814
General-Use Snap Switches	UL 20
Ground-Fault Circuit-Interrupters	UL 943
Ground-Fault Sensing and Relaying Equipment	UL 1053
Grounding and Bonding Equipment	UL 467
Hardware for the Support of Conduit, Tubing and Cable	UL 2239
Heating and Cooling Equipment	UL 1995
High-Intensity-Discharge Lamp Ballasts	UL 1029
• Household and Similar Electrical Appliances, Part 2: Particular Requirements for Heating and Cooling	UL 60335-2-40
Household and Similar Electrical Appliances, Part 2: Particular Requirements for Refrigerating Appliances, Ice-Cream Appliances, and Ice-makers	UL 60335-2-24
Household Refrigerators and Freezers	UL 250
Impedance Protected Motors	UL 1004-2
Industrial Battery Chargers	UL 1564
Industrial Control Equipment	UL 508
Industrial Control Panels	UL 508A
Information Technology Equipment Safety — Part 1: General Requirements	UL 60950-1
Information Technology Equipment Safety — Part 21: Remote Power Feeding	UL 60950-21
Information Technology Equipment Safety — Part 22: Equipment to be Installed Outdoors	UL 60950-22
Information Technology Equipment Safety — Part 23: Large Data Storage Equipment	UL 60950-23
Instrumentation Tray Cable	UL 2250
Insulated Multi-Pole Splicing Wire Connectors	UL 2459
Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources	UL 1741
Isolated Power Systems Equipment	UL 1047
Junction Boxes for Swimming Pool Luminaires	UL 1241
Light Emitting Diode (LED) Equipment for Use in Lighting Products	UL 8750
Liquid Fuel-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles	UL 307A
Liquid-Tight Flexible Nonmetallic Conduit	UL 1660
Liquid-Tight Flexible Steel Conduit	UL 360
Lithium Batteries	UL 1642
Low-Voltage Fuses — Fuses for Photovoltaic Systems	Subject 2579
Low-Voltage Fuses — Part 1: General Requirements	UL 248-1
Low-Voltage Fuses — Part 2: Class C Fuses	UL 248-2
Low-Voltage Fuses — Part 3: Class CA and CB Fuses	UL 248-3
Low-Voltage Fuses — Part 4: Class CC Fuses	UL 248-4
Low-Voltage Fuses — Part 5: Class G Fuses	UL 248-5
Low-Voltage Fuses — Part 6: Class H Renewable Fuses	UL 248-6
Low-Voltage Fuses — Part 7: Class H Renewable Fuses	UL 248-7
Low-Voltage Fuses — Part 8: Class J Fuses	UL 248-8
Low-Voltage Fuses — Part 9: Class K Fuses	UL 248-9
Low-Voltage Fuses — Part 10: Class L Fuses	UL 249-10
Low-Voltage Fuses — Part 11: Plug Fuses	UL 248-11
Low-Voltage Fuses — Part 12: Class R Fuses	UL 248-12
Low-Voltage Fuses — Part 13: Semiconductor Fuses	UL 248-13
Low-Voltage Fuses — Part 14: Supplemental Fuses	UL 248-14

Product Standard Name	Product Standard Number
Low-Voltage Fuses — Part 15: Class T Fuses	UL 248-15
Low-Voltage Fuses — Part 16: Test Limiters	UL 248-16
Low-Voltage Landscape Lighting Systems	UL 1838
Low-Voltage Lighting Fixtures for Use in Recreational Vehicles	UL 234
Low-Voltage Lighting Systems	UL 2108
Low-Voltage Switchgear and Controlgear — Part 4-1A: Contactors and Motor-Starters — Electromechanical Contactors and Motor-Starters	UL 60947-4-1A
Low-Voltage Switchgear and Controlgear — Part 5-2: Control Circuit Devices and Switching Elements — Proximity Switches	UL 60947-5-2
Low Voltage Transformers — Part 1: General Requirements	UL 5085-1
Low Voltage Transformers — Part 3: Class 2 and Class 3 Transformers	UL 5085-3
Luminaire Reflector Kits for Installation on Previously Installed Fluorescent Luminaires, Supplemental Requirements	UL 1598B
Luminaires	UL 1598
Machine-Tool Wires and Cables	UL 1063
Manufactured Wiring Systems	UL 183
Medical Electrical Equipment — Part 1: General Requirements for Safety	UL 60601-1
Medium-Voltage AC Contactors, Controllers, and Control Centers	UL 347
Medium-Voltage Power Cables	UL 1072
Metal-Clad Cables	UL 1569
• Metallic Outlet Boxes	UL 514A
Mobile Home Pipe Heating Cable	Subject 1462
Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	UL 489
Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures for Use with Photovoltaic (PV) Systems	Subject 489B
Motor Control Centers	UL 845
Motor-Operated Appliances	UL 73
Multi-Pole Connectors for Use in Photovoltaic Systems	Subject 6703A
Neon Transformers and Power Supplies	UL 2161
Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations	ANSI/ISA-12.12.01
Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers	UL 514C
Nonmetallic Surface Raceways and Fittings	UL 5A
Nonmetallic Underground Conduit with Conductors	UL 1990
Office Furnishings	UL 1286
Optical Fiber Cable	UL 1651
Optical Fiber and Communication Cable Raceway	UL 2024
Panelboards	UL 67
Performance Requirements of Detectors for Flammable Gases	ANSI/ISA-60079-29-1
Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits ;Part 1: General Requirements	UL 2231-1
Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits; Part 2: Particular Requirements for Protection Devices for Use in Charging Systems	UL 2231-2
Photovoltaic DC Arc-Fault Circuit Protection	Subject 1699B
Photovoltaic Junction Boxes	Subject 3730
Photovoltaic Wire	Subject 4703
Plugs, Receptacles and Couplers for Electrical Vehicles	UL 2251
Portable Electric Luminaires	UL 153
Portable Power-Distribution Equipment	UL 1640
Potting Compounds for Swimming Pool, Fountain, and Spa Equipment	UL 676A
Power Conversion Equipment	UL 508C
Power Outlets	UL 231
Power Units Other Than Class 2	UL 1012
Power-Limited Circuit Cables	UL 13
Professional Video and Audio Equipment	UL 1419
Programmable Controllers – Part 2: Equipment Requirements and Tests	UL 61131-2
Protectors for Coaxial Communications Circuits	UL 497C
Protectors for Data Communication and Fire Alarm Circuits	UL 497B
Protectors for Paired-Conductor Communications Circuits	UL 497
• Reference Standard for Electrical Wires, Cables, and Flexible Cords	UL 1581
• Requirements for Process Sealing Between Electrical Systems and Potentially Flammable or Combustible Process Fluids	ANSI/ISA-12.27.01
Residential Pipe Heating Cable	Subject 2049
Roof and Gutter De-Icing Cable Units	Subject 1588
Room Air Conditioners	UL 484
• Rotating Electrical Machines — General Requirements	UL 1004-1
Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings	UL 651
Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit	UL 651A
Sealed Wire Connector Systems	UL 486D
Seasonal and Holiday Decorative Products	UL 588
Secondary Protectors for Communications Circuits	UL 497A
Self-Ballasted Lamps and Lamp Adapters	UL 1993
Service-Entrance Cables	UL 854
Smoke Detectors for Fire Alarm Signaling Systems	UL 268
Solar Trackers	Subject 3703
Specialty Transformers	UL 506
Splicing Wire Connectors	UL 486C

Product Standard Name	Product Standard Number
Stage and Studio Luminaires and Connector Strips	UL 1573
Standby Batteries	UL 1989
Stationary Engine Generator Assemblies	UL 2200
Strut-Type Channel Raceways and Fittings	UL 5B
Supplemental Requirements for Extra-Heavy Wall Reinforced Thermosetting Resin Conduit (RTRC) and Fittings	UL 2515A
Surface Metal Raceways and Fittings	UL 5
Surface Raceways and Fittings for Use with Data, Signal and Control Circuits	UL 5C
Surge Arresters — Gapped Silicon-Carbide Surge Arresters for AC Power Circuits	IEEE C62.1
Surge Arresters — Metal-Oxide Surge Arresters for AC Power Circuits	IEEE C62.11
Surge Protective Devices	UL 1449
Swimming Pool Pumps, Filters, and Chlorinators	UL 1081
Switchboards	UL 891
• Thermally Protected Motors	UL 1004-3
• Transfer Switch Equipment	UL 1008
• Underfloor Raceways and Fittings	UL 884
Underwater Luminaires and Submersible Junction Boxes	UL 676
Uninterruptible Power Systems	UL 1778
Vacuum Cleaners, Blower Cleaners, and Household Floor Finishing Machines	UL 1017
Waste Disposers	UL 430
Wind Turbine Generating Systems	Subject 6140
Wind Turbine Generating Systems — Small	Subject 6142
Wire Connectors	UL 486A, UL 486B
Wireways, Auxiliary Gutters, and Associated Fittings	UL 870