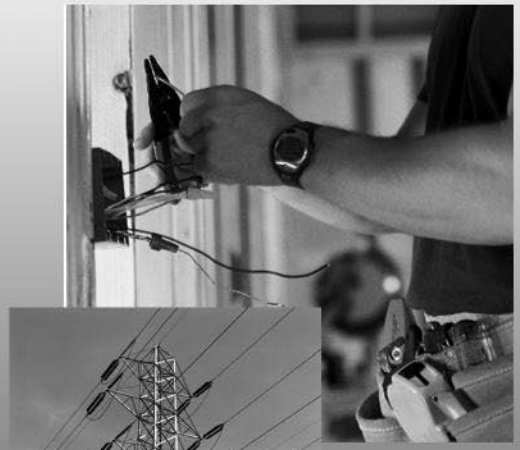


Continuing Education For Limited License Electricians

CETC CONNECTICUT ELECTRICAL Training Center, LLC

2025 Edition

EVALUATION FORMS:

The procedure for submitting the evaluation form for electrical continuing education courses has been moved to an online format. Please access the following link to complete and submit the form:

https://portal.ct.gov/ELCeval

2025 Continuing Education for Electricians

(For All Electrical License Holders)

Part 1 - Connecticut General Statutes

Sec. 20-340. Exemptions from licensing requirements

The provisions of this chapter shall not apply to: (1) Persons employed by any federal, state or municipal agency; (2) employees of any public service company regulated by the Public Utilities Regulatory Authority or of any corporate affiliate of any such company when the work performed by such affiliate is on behalf of a public service company, but in either case only if the work performed is in connection with the rendition of public utility service, including the installation or maintenance of wire for community antenna television service, or is in connection with the installation or maintenance of wire or telephone sets for single-line telephone service located inside the premises of a consumer; (3) employees of any municipal corporation specially chartered by this state; (4) employees of any contractor while such contractor is performing electrical-line or emergency work for any public service company; (5) persons engaged in the installation, maintenance, repair and service of electrical or other appliances of a size customarily used for domestic use where such installation commences at an outlet receptacle or connection previously installed by persons licensed to do the same and maintenance, repair and service is confined to the appliance itself and its internal operation; (6) employees of industrial firms whose main duties concern the maintenance of the electrical work, plumbing and piping work, solar thermal work, heating, piping, cooling work, sheet metal work, elevator installation, repair and maintenance work, automotive glass work or flat glass work of such firm on its own premises or on premises leased by it for its own use; (7) employees of industrial firms when such employees' main duties concern the fabrication of glass products or electrical, plumbing and piping, fire protection sprinkler systems, solar, heating, piping, cooling, chemical piping, sheet metal or elevator installation, repair and maintenance equipment used in the production of goods sold by industrial firms, except for products, electrical, plumbing and piping systems and repair and maintenance equipment used directly in the production of a product for human consumption; (8) persons performing work necessary to the manufacture or repair of any apparatus, appliances, fixtures, equipment or devices produced by it for sale or lease; (9) employees of stage and theatrical companies performing the operation, installation and maintenance of electrical equipment if such installation commences at an outlet receptacle or connection previously installed by persons licensed to make such installation; (10) employees of carnivals, circuses or similar transient amusement shows who install electrical work, provided such installation shall be subject to the approval of the State Fire Marshal prior to use as otherwise provided by law and shall comply with applicable municipal ordinances and regulations; (11) persons engaged in the installation, maintenance, repair and service of glass or electrical, plumbing, fire protection sprinkler systems, solar, heating, piping, cooling and sheet metal equipment in and about single-family residences owned and occupied or to be occupied by such persons; provided any such installation, maintenance and repair shall be subject to inspection and approval by the building official of the municipality in which such residence is located and shall conform to the requirements of the State Building Code; (12) persons who install, maintain or repair glass in a motor vehicle owned or leased by such persons; (13) persons or entities holding themselves out to be retail sellers of glass products, but not such persons or entities that also engage in automotive glass work or flat glass work; (14) persons who install preglazed or preassembled windows or doors in residential or commercial buildings; (15) persons registered under chapter 400 who install safety-backed mirror products or repair or replace flat glass in sizes not greater than thirty square feet in residential buildings; (16) sheet metal work performed in residential

buildings consisting of six units or less by new home construction contractors registered pursuant to chapter 399a, by home improvement contractors registered pursuant to chapter 400 or by persons licensed pursuant to this chapter, when such work is limited to exhaust systems installed for hoods and fans in kitchens and baths, clothes dryer exhaust systems, radon vent systems, fireplaces, fireplace flues, masonry chimneys or prefabricated metal chimneys rated by Underwriters Laboratories or installation of stand-alone appliances including wood, pellet or other stand-alone stoves that are installed in residential buildings by such contractors or persons; (17) employees of or any contractor employed by and under the direction of a properly licensed solar contractor, performing work limited to the hoisting, placement and anchoring of solar collectors, photovoltaic panels, towers or turbines; (18) persons performing swimming pool maintenance and repair work authorized pursuant to section 20-417aa; and (19) any employee of the Connecticut Airport Authority covered by a state collective bargaining agreement.

Sec. 20-332-15a. Employment of apprentices

(a) Nothing in Chapter 393 of the General Statutes shall be construed to prohibit the employment of apprentices.

(b) An apprentice may perform the work for which he is being trained only in the presence and under the direct supervision of a licensed contractor or journeyman in his trade, and shall comply with all the regulations pertaining thereto.

(c) No apprentice shall at any time engage in any of the work for which a license is required without direct supervision. Direct supervision shall mean under the guidance of a licensed contractor or journeyman and within the sight and/or hearing of said licensed person.

(d) Any person who encourages or permits an apprentice or helper to so engage in the work or occupation for which a license is required without direct supervision shall also be subject to appropriate disciplinary action. The contractor who obtains the permit for the work for which a license is required shall be deemed to have encouraged or permitted the apprentice or helper to work without direct supervision for the purpose of disciplinary action by the appropriate board.

(f) How to register as an apprentice.

(1) No apprentice shall perform the work of any occupation covered by Chapter 393 of the General Statutes unless he has first obtained a card of registration from the Connecticut Department of Labor.

(2) Prior to employing an apprentice, the contractor shall communicate immediately with the Connecticut Department of Labor to request registration of said apprentice.

(3) When registration is requested for an area of the trade which is not available through the Connecticut Department of Labor, said contractor shall make his request to the appropriate board prior to the employment of the apprentice.

Sec. 20-332-16. Prohibited acts. Records. Lettering on commercial vehicles

(a) Any licensee who installs, performs or directs the performance of work in violation of any applicable state statute, state code, or state regulation, any municipal code or ordinance, any of these regulations, or who violates generally accepted basic trade practices shall be subject to disciplinary action by the appropriate board.
(b) Licensed contractors alone shall be permitted to acquire building permits to perform work covered by chapter 393 of the General Statutes and the regulations promulgated thereunder. In order to apply for a building permit to perform work covered by chapter 393 of the General Statutes and the regulations adopted thereunder a contractor shall be directly employed by the business on a regular and full time basis. In applying for the building permit to perform work covered by chapter 393 of the General Statutes and the regulations promulgated thereunder the contractor is attesting to the fact that he is responsible for and will directly supervise the work being performed under said permit. Except as provided for in Section 20-338b of the General Statutes, the licensed contractor must sign each building permit application personally and may not delegate the signing of the permit to any employee, subcontractor or other agent. Any licensed contractor who violates these regulations shall be subject to disciplinary action by the appropriate board.
(c) No licensee shall engage in or offer to engage in business under any name other than that stated on his application for a license unless he has notified the board ten days prior to using the new name.
(d) Any holder of a journeyman's license who performs work without being in the direct and regular employ of a properly licensed contractor shall be subject to disciplinary action by the appropriate board.
(e) All licensed contractors shall keep a record of all employees they employ and exhibit such records to the Commissioner or her agents upon request.
(f) No one shall perform any work beyond the limitations stated on his license regardless of the type of license his employer holds. Further, no one holding a limited

or unlimited journeyman's license can perform any work beyond the limitations of the license held by the contractor for whom he is employed.
(g) The lettering of the state license numbers required to be displayed on all commercial vehicles used in the contractor's business shall be at least one inch high and legible.
(h) Any holder of a contractor's license who installs, performs or directs the performance of work for which a building permit is required shall cause said performance of work to be performed by a person licensed or registered under the provisions of Section 20-334 of the General Statutes. The contractor who obtains the building permit shall be deemed to have caused or directed the performance of all work performed under the building permit.
(i) No person shall use solder containing mre than 0.2 per cent lead in making joints and fitting in any public or private plumbing, heating or cooling system, or fire protection system as defined in Sections 20-330 (3), 20-330- (5) and 20-330 (9) of the general statutes.

Sec. 20-332b. Hiring ratios re apprentices, journeymen and contractors. Electrical, plumbing, heating, piping and cooling, sprinkler fitter and sheet metal work. Regulations. The Commissioner of Consumer Protection shall amend existing regulations of Connecticut state agencies adopted pursuant to section 20-332 to specify the following allowable hiring ratios regarding apprentices, journeymen and contractors for the following trades:

TRADE

Electrical, Plumbing, Heating, Piping and Cooling, Sprinkler Fitter and Sheet Metal Work

Apprentices	Licensees (Journeymen or Contractors)
1	1
2	2
3	3
4	6
5	9
6	12
7	15
8	18
9	21
10	24

Ratio continues at 3 Journeypersons To 1 Apprentice

Sec. 20-332c. Apprentice, journeymen and contractor working group established. Membership. Report. (a) There is established a working group to discuss hiring ratios for apprentices, journeymen and contractors and study the hiring ratio relief process. The working group shall meet at least three times annually and shall study and make recommendations related to apprentices, journeymen and contractors.

(b) The working group shall consist of ten members, and shall be evenly divided between members of the following union and nonunion industry trade groups: The International Brotherhood of Electrical Workers, the Independent Electrical Contractors of New England, the Associated Builders and Contractors of Connecticut, Sheet Metal Local 40, Sprinkler Fitters Local 669, the Connecticut Chapter of American Fire Sprinkler Association, the United Association of Plumbers and Pipefitters Local 777, the Plumbing Heating and Cooling Contractors of Connecticut, the Connecticut Heating and Cooling Contractors and the Connecticut State Building and Construction Trades Council. Each union industry trade group member shall be either the business manager of such group or such business manager's designee

from such group. Each nonunion industry trade group member shall be either the president of such group or such president's designee from such group.

(c) Such members shall be selected as follows:
(1) Two union members appointed by the speaker of the House of Representatives;
(2) Two union members appointed by the president pro tempore of the Senate;
(3) One nonunion member appointed by the majority leader of the House of Representatives;
(4) One union member appointed by the majority leader of the Senate;
(5) Two nonunion members appointed by the minority leader of the House of Representatives; and
(6) Two nonunion members appointed by the minority leader of the Senate.
(d) All appointing authorities shall consult with the chairpersons and ranking members of the joint standing committee of the General Assembly having cognizance of matters relating to the Department of Consumer Protection prior to making any appointments pursuant to this section.
(e) All appointments to the working group shall be made not later than thirty days after the effective date of this section. Any vacancy shall be filled by the appointing authority.
(f) The members of the working group shall select the chairpersons of the working group from among the members of the group. One chairperson shall be a union member and one chairperson shall be a nonunion member. Such chairpersons shall schedule the first meeting of the working group.

(g) The administrative staff of the joint standing committee of the General Assembly having cognizance of matters relating to the Department of Consumer Protection shall serve as administrative staff of the working group.
(h) Not later than December 1, 2017, and annually thereafter, the working group shall submit a report on its recommendations to the joint standing committee of the General Assembly having cognizance of matters relating to the Department of Consumer Protection, in accordance with the provisions of section 11-4a.

Sec. 20-335. License fee. Continuing professional education requirements. Expiration and renewal. Any person who has successfully completed an examination for such person’s initial license under this chapter shall pay to the Department of Consumer Protection a fee of one hundred fifty dollars for a contractor’s license or a fee of one hundred twenty dollars for any other such license. All such licenses shall expire annually. No person shall carry on or engage in the work or occupations subject to this chapter after the expiration of such person’s license until such person has filed an application bearing the date of such person’s registration card with the appropriate board. Such application shall be in writing, addressed to the secretary of the board from which such renewal is sought and signed by the person applying for such renewal. A licensee applying for renewal shall, at such times as the commissioner shall by regulation prescribe, furnish evidence satisfactory to the board that the licensee has completed any continuing professional education required under sections 20-330 to 20-341, inclusive, or any regulations adopted thereunder. The board may renew such license if the application for such renewal is received by the board no later than one month after the date of expiration of such license, upon payment to the department of a renewal fee of one hundred fifty dollars in the case

of a contractor and of one hundred twenty dollars for any other such license. For any completed renewal application submitted pursuant to this section that requires a hearing or other action by the applicable examining board, such hearing or other action by the applicable examining board shall occur not later than thirty days after the date of submission for such completed renewal application. The department shall issue a receipt stating the fact of such payment, which receipt shall be a license to engage in such work or occupation. A licensee who has failed to renew such licensee's license for a period of over one year from the date of expiration of such license shall have it reinstated only upon complying with the requirements of section 20-333. All license fees and renewal fees paid to the department pursuant to this section shall be deposited in the General Fund.

Sec. 20-338. License as contractor and journeyman. Valid throughout state. The Department of Consumer Protection shall issue a separate license to persons qualified to engage in work as contractors and as journeymen. Any person licensed under this chapter shall be permitted to perform the work or occupation covered by such license in any town or municipality of this state without further examination or licensing by any town or municipality.

Sec. 20-338a. Work required to be performed by licensed persons. Any contractor who applies for a building permit from a local building official for any work required to be performed by a person licensed under the provisions of this chapter, shall cause such work to be performed by a person licensed under the provisions of this chapter.

Sec. 20-338b. Building permit applications. Who may sign. Any licensed contractor who seeks to obtain a permit from a building official may sign the building permit application personally or delegate the signing of the building permit application to an employee, subcontractor or other agent of the licensed contractor, provided, the licensed contractor's employee, subcontractor or other agent submits to the building official a dated letter on the licensed contractor's letterhead, signed by the licensed contractor, stating that the bearer of the letter is authorized to sign the building permit application as the agent of the licensed contractor. The letter shall not be a copy or a facsimile, but shall be an original letter bearing the original signature of the licensed contractor. The letter shall also include: (1) The name of the municipality where the work is to be performed; (2) the job name or a description of the job; (3) the starting date of the job; (4) the name of the licensed contractor; (5) the name of the licensed contractor's agent; and (6) the license numbers of all contractors to be involved in the work.

Sec. 20-338c. Work not to commence until permit obtained. No person licensed pursuant to sections 20-330 to 20-341, inclusive, shall commence work within the scope of sections 20-330 to 20-341, inclusive, unless each applicable permit with respect to the specific work being performed by such licensee has been obtained as required pursuant to local ordinances and the general statutes.

Sec. 20-340. Exemptions from licensing requirements. The provisions of this chapter shall not apply to: (1) Persons employed by any federal, state or municipal agency; (2) employees of any public service company regulated by the Public Utilities Regulatory Authority or of any corporate affiliate of any such company when the work performed by such affiliate is on behalf

of a public service company, but in either case only if the work performed is in connection with the rendition of public utility service, including the installation or maintenance of wire for community antenna television service, or is in connection with the installation or maintenance of wire or telephone sets for single-line telephone service located inside the premises of a consumer; (3) employees of any municipal corporation specially chartered by this state; (4) employees of any contractor while such contractor is performing electrical-line or emergency work for any public service company; (5) persons engaged in the installation, maintenance, repair and service of electrical or other appliances of a size customarily used for domestic use where such installation commences at an outlet receptacle or connection previously installed by persons licensed to do the same and maintenance, repair and service is confined to the appliance itself and its internal operation; (6) employees of industrial firms whose main duties concern the maintenance of the electrical work, plumbing and piping work, solar thermal work, heating, piping, cooling work, sheet metal work, elevator installation, repair and maintenance work, automotive glass work or flat glass work of such firm on its own premises or on premises leased by it for its own use; (7) employees of industrial firms when such employees' main duties concern the fabrication of glass products or electrical, plumbing and piping, fire protection sprinkler systems, solar, heating, piping, cooling, chemical piping, sheet metal or elevator installation, repair and maintenance equipment used in the production of goods sold by industrial firms, except for products, electrical, plumbing and piping systems and repair and maintenance equipment used directly in the production of a product for human consumption; (8) persons performing work necessary to the manufacture or repair of any apparatus, appliances, fixtures, equipment or devices produced by it for sale or lease; (9) employees of stage and theatrical companies performing the operation, installation and maintenance of electrical equipment if such installation commences at an outlet receptacle or connection previously installed by persons licensed to make such installation; (10) employees of carnivals, circuses or similar transient amusement shows who install electrical work, provided such installation shall be subject to the approval of the State Fire Marshal prior to use as otherwise provided by law and shall comply with applicable municipal ordinances and regulations; (11) persons engaged in the installation, maintenance, repair and service of glass or electrical, plumbing, fire protection sprinkler systems, solar, heating, piping, cooling and sheet metal equipment in and about single-family residences owned and occupied or to be occupied by such persons; provided any such installation, maintenance and repair shall be subject to inspection and approval by the building official of the municipality in which such residence is located and shall conform to the requirements of the State Building Code; (12) persons who install, maintain or repair glass in a motor vehicle owned or leased by such persons; (13) persons or entities holding themselves out to be retail sellers of glass products, but not such persons or entities that also engage in automotive glass work or flat glass work; (14) persons who install preglazed or preassembled windows or doors in residential or commercial buildings; (15) persons registered under chapter 400 who install safety-backed mirror products or repair or replace flat glass in sizes not greater than thirty square feet in residential buildings; (16) sheet metal work performed in residential buildings consisting of six

units or less by new home construction contractors registered pursuant to chapter 399a, by home improvement contractors registered pursuant to chapter 400 or by persons licensed pursuant to this chapter, when such work is limited to exhaust systems installed for hoods and fans in kitchens and baths, clothes dryer exhaust systems, radon vent systems, fireplaces, fireplace flues, masonry chimneys or prefabricated metal chimneys rated by Underwriters Laboratories or installation of stand-alone appliances including wood, pellet or other stand-alone stoves that are installed in residential buildings by such contractors or persons; (17) employees of or any contractor employed by and under the direction of a properly licensed solar contractor, performing work limited to the hoisting, placement and anchoring of solar collectors, photovoltaic panels, towers or turbines; and (18) persons performing swimming pool maintenance and repair work authorized pursuant to section 20-417aa.

Sec. 20-341. Penalties for violations. (a) Any person who wilfully engages in or practices the work or occupation for which a license is required by this chapter or chapter 399b without having first obtained an apprentice permit or a certificate and license for such work, as applicable, or who wilfully employs or supplies for employment a person who does not have a certificate and license for such work, or who wilfully and falsely pretends to qualify to engage in or practice such work or occupation, including, but not limited to, offering to perform such work in any print, electronic, television or radio advertising or listing when such person does not hold a license for such work as required by this chapter, or who wilfully engages in or practices any of the work or occupations for which a license is required by this chapter after the expiration of such person's license, shall be guilty of a class B misdemeanor, provided no criminal charges shall be instituted against such person pursuant to this subsection unless the work activity in question is reviewed by the Commissioner of Consumer Protection, or the commissioner's authorized agent, and the commissioner or such agent specifically determines, in writing, that such work activity requires a license and is not the subject of a bona fide dispute between persons engaged in any trade or craft, whether licensed or unlicensed. Notwithstanding the provisions of subsection (d) or (e) of section 53a-29 and subsection (d) of section 54-56e, if the court determines that such person cannot fully repay any victims of such person within the period of probation established in subsection (d) or (e) of section 53a-29 or subsection (d) of section 54-56e, the court may impose probation for a period of not more than five years. The penalty provided in this subsection shall be in addition to any other penalties and remedies available under this chapter or chapter 416.

(b) The appropriate examining board or the Commissioner of Consumer Protection may, after notice and hearing, impose a civil penalty on any person who engages in or practices the work or occupation for which a license or apprentice registration certificate is required by this chapter, chapter 394, chapter 399b or chapter 482 without having first obtained such a license or certificate, or who wilfully employs or supplies for employment a person who does not have such a license or certificate or who wilfully and falsely pretends to qualify to engage in or practice such work or occupation, or who engages in or practices any of the work or occupations for which a license or certificate is required by this chapter, chapter 394, chapter 399b or chapter 482 after the expiration of the license or certificate or who violates any of the provisions of this chapter, chapter 394, chapter 399b or chapter 482 or the regulations adopted pursuant thereto. Such penalty shall be in an amount not more than one thousand dollars for a first violation of this

subsection, not more than one thousand five hundred dollars for a second violation of this subsection and not more than three thousand dollars for each violation of this subsection occurring less than three years after a second or subsequent violation of this subsection, except that any individual employed as an apprentice but improperly registered shall not be penalized for a first offense.

(c) If an examining board or the Commissioner of Consumer Protection imposes a civil penalty under the provisions of subsection (b) of this section as a result of a violation initially reported by a municipal building official in accordance with subsection (c) of section 29-261, the commissioner shall, not less than sixty days after collecting such civil penalty, remit one-half of the amount collected to such municipality.

(d) A violation of any of the provisions of this chapter shall be deemed an unfair or deceptive trade practice under subsection (a) of section 42-110b.

(e) This section shall not apply to any person who (1) holds a license issued under this chapter, chapter 394, chapter 399b or chapter 482 and performs work that is incidentally, directly and immediately appropriate to the performance of such person’s trade where such work commences at an outlet, receptacle or connection previously installed by a person holding the proper license, or (2) engages in work that does not require a license under this chapter, chapter 394, chapter 399b or chapter 482.

The following is a link to Public Act 22-104

https://www.cga.ct.gov/2022/act/Pa/pdf/2022PA-00104-R00HB-05330-PA.PDF

Sec. 37. (NEW) (Effective July 1, 2022) Any contractor who is licensed under chapter 393 of the general statutes and engaged to perform work on a private residence, and any person who owns or controls a business that is engaged to perform work on, or render services concerning, a private residence through persons licensed under chapter 393 of the general statutes to perform such work or render such services, shall include in the invoice or work order for such work or services, provided such invoice or work order is not signed by the consumer and therefore may constitute a contract, when complete: (1) The full legal name and license number of such licensed contractor or the licensed contractor of record for such business for such work or services, which licensed contractor or licensed contractor of record is liable for the work of any individual who performs work on such contractor's behalf related to the invoiced work or services; (2) such licensed contractor's address or, in the case of a business, the business's address and phone number; (3) a description of such work or services; (4) the labor and material costs of such work or services; (5) the date or dates on which such work was performed or services were rendered; and (6) the complete name of each licensee who performed such work or rendered such services. For the purposes of this section, "private residence" has the same meaning as provided in section 20-419 of the general statutes.

Sec. 42. Section 20-334d of the general statutes is repealed and the following is substituted in lieu thereof (Effective from passage):

(a) As used in this section:

(1) "Accredited continuing professional education" means any education of an electrician or plumber that is (A) designed to maintain professional competence in the [pursuit,] practice, pursuit and standards of electrical work or plumbing and piping work, [and that is] (B) approved by the commissioner, and [is] (C) provided (i) by an agency, institution or organization [, institution or agency that is] that has been approved by the commissioner, and (ii) in-person or through an online technology platform that includes real-time video with audio, requires participants to periodically confirm their active engagement during the educational training session and enables participants to interact with instructors in real time during the entire educational training session;

(2) "Certificate of continuing education" means a document [issued to an electrician or plumber by an organization, institution or agency] that (A) an agency, institution or organization that has been approved by the commissioner [that] and offers accredited continuing professional education [, which (A)] issues to an electrician or plumber, (B) certifies that an electrician or plumber has satisfactorily completed a specified number of continuing education hours, and [(B)] (C) bears the (i) name of such agency, institution or organization, [institution or agency, the] (ii) title of the program, [the] (iii) dates during which the program was

conducted, [the] (iv) number of continuing education hours

satisfactorily completed, and [the] (v) signature of the director of such

[organization, institution or agency or the signature of the] agency,

institution or organization or of such director's authorized agent; and (3) "Commissioner" means the Commissioner of Consumer Protection. (b) The commissioner, with the advice and assistance of the Electrical Work Board established pursuant to subsection (b) of section 20-331, shall adopt regulations, in accordance with chapter 54, to: (1) [establish] Establish additional requirements for accredited continuing professional education for electricians licensed pursuant to sections 20- 330 to 20-341, inclusive; (2) establish qualifying criteria for accredited continuing professional education programs and establish qualifying criteria for acceptable certificates of continuing education; and (3) provide for the waiver of required accredited continuing professional education for electricians for good cause. Such regulations shall require not less than four hours per year of accredited continuing professional education for such electricians, except upon request of the Electrical Work Board, the commissioner may increase such hours to a maximum of seven hours. (c) The commissioner, with the advice and assistance of the Plumbing and Piping Work Board established pursuant to subsection (d) of section 20-331, shall adopt regulations, in accordance with chapter 54, to: (1) [establish] Establish additional requirements for accredited continuing professional education for plumbers licensed pursuant to sections 20-330 to 20-341, inclusive, which regulations shall require not more than a total of seven hours of accredited continuing professional education every two years, except in the event of significant changes to the building code, as approved by the International Code Council, that relate to plumbing, the commissioner, at such commissioner's discretion, may require more than a total of seven hours of accredited continuing professional education every two years; (2) establish qualifying criteria for accredited continuing professional education programs and establish qualifying criteria for acceptable certificates of continuing education; and (3) provide for the waiver of required accredited continuing professional education for plumbers for good cause. (d) Notwithstanding the provisions of subsection (c) of this section, any person who has been issued a P-6, P-7, W-8 or W-9 license pursuant to section 20-334a and the regulations of Connecticut state

agencies shall not be required to meet the continuing education requirements established pursuant to subsection (c) of this section. (e) Notwithstanding the provisions of subsections (a) to (d), inclusive, of this section, all accredited continuing professional education offered under the provisions of this section shall: (1) Limit class size to (A) fifty attendees if such accredited continuing professional education is offered in-person, or (B) twenty-five attendees if such accredited continuing professional education is offered through an online technology platform; (2) not be offered or held at the place of business of a licensed plumbing contractor if such accredited continuing professional education is for plumbers and offered in-person; and (3) not be offered or held at the place of business of a licensed electrical contractor if such accredited continuing professional education is for electricians and offered in-person. A provider of an accredited continuing professional education course shall retain an audio-visual recording of such course for a period of not less than thirty days after completion of such course. Recordings shall be made available to the department upon the department's request for such recordings.

Dear Registered Apprenticeship Sponsor,

This letter is to inform you of new state reporting requirements and to request your collaboration in gathering this data. Connecticut General Statutes Section 31-22r(c) requires all Registered Apprenticeship sponsors to submit information along with their annual registration fee. Details provided on this form by sponsors will become public record.

To ensure effective processing, please fill in the requested information below and return this form to CTDOL/OAT with your annual Registered Apprentice renewal forms and payments.

Company Name:_____

Company Address:_____

Instructions for this form:
For each response below, please further break down the number by the categories below as follows:

1. The percentage of Registered Apprentices that completed the sponsor's program since 7/1/2023:_____

   Of that number, provide the percentage based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

2. Total number of Registered Apprentices currently participating in sponsor's program:_____

Of that amount, provide the number based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

3. Number of current journeypersons (including licensed journeypersons, contractors, and contractor of record if applicable) currently employed by sponsor :_____

Of that amount, provide the number based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

4. Number of Registered Apprentices who have advanced a year (or step) of their apprenticeship since the date of sponsor's previous registration, or year to date for new sponsors: _____

Of that amount, provide the number based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

5. Number of Registered Apprentices who have separated from such sponsor's program since the date of sponsor's previous annual registration, or year to date for new sponsor (how many Registered Apprentices left the program since your last registration):_____

Of that amount, provide the number based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

6. Number of Registered Apprentices who have completed an apprenticeship program since the previous registration (or year to-date for new sponsors):_____

Of that amount, provide the number based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

7. Number of Registered Apprentices who completed the program, AND are currently employed by the sponsor, AND (if applicable) have been issued an occupational license by the Department of Consumer Protection:_____

Of that amount, provide the number based on the following categories:

Gender Identity	Ethnicity	Race
Female _____	Hispanic or Latino _____	White, Non-Hispanic _____
Male _____	Not Hispanic or Latino _____	Black/African American _____
Non-Binary _____	Unknown _____	American Indian or Alaska Native_____
Unknown _____		Native Hawaiian or Other Pacific Islander_____
		Asian _____
		Two or more _____
		Unknown _____

2022 Connecticut State Building Code: (Include in all course handouts to attendees for their future use and review with class.)

Building and Fire Code Adoption Process

State Building, Fire Safety and Fire Prevention Codes Update

The Department of Administrative Services, Office of the State Building Inspector and Office of the State Fire Marshal, in conjunction with the Codes & Standards Committee and the Fire Prevention Code Advisory Committee, intend to adopt the following new codes, effective October 1, 2022:

- 2022 Connecticut State Building Code (CSBC)
- 2022 Connecticut State Fire Safety Code (CSFSC)
- 2022 Connecticut State Fire Prevention Code (CSFPC)

In accordance with the requirements of sections 29-252b, 29-292a and 29-291e of the Connecticut General Statues, the agency accepted comments from the public for a period of forty-five (45) days, beginning January 31, 2022 through the close of business March 17, 2022.

The comments received are now being considered for incorporation into the draft codes ahead of their submission of legislative review.

Draft 2022 State Codes

• The public comment drafts of the three proposed codes are available under Documents/Forms

• The legislative approval drafts of the three proposed codes are being prepared.

Proposed Model Codes:

The following codes are proposed to be adopted into the next state codes:

• 2021 International Building Code (IBC) by the ICC

• 2021 International Existing Building Code (IEBC) by the ICC

• 2021 International Energy Conservation Code (IECC) by the ICC

• 2021 International Mechanical Code (IMC) by the ICC

• 2021 International Plumbing Code (IPC) by the ICC

• 2021 International Residential Code (IRC) by the ICC

• 2021 International Swimming Pool & Spa Code (ISPSC) by the ICC

• 2020 NFPA 70 National Electrical Code (NEC) by NFPA

• 2017 ICC A117.1 Accessible and Usable Buildings and Facilities by the ICC

• 2021 International Fire Code (IFC) by the ICC

• 2021 NFPA 101 - Life Safety Code by the NFPA

• 2021 NFPA 1 - Fire Code by the NFPA

The model codes are viewable on their publisher's web sites:

- International Code Council (ICC) Codes
- National Fire Protection Association (NFPA) Codes

https://portal.ct.gov/DAS/Office-of-State-Building-Inspector/Building-and-Fire-Code-Adoption-Process/Documents

NOTE: Always refer to the State Building Officials website indicated above for all the most currently adopted codes and "AMENDMENTS" to the codes.

Finding State Building Code Interpretations

The State Building Inspector issues formal interpretations of the State Building Code pursuant to the authority granted by Section 29-252 of the Connecticut General Statutes. These interpretations may be issued at the request of a local building official or by the general public. The final interpretations are the opinion of the State Building Inspector.

The state building code interpretations can be found at the following web address:

https://portal.ct.gov/DAS/Office-of-State-Building-Inspector/State-Building-Code-Interpretations

2025 Continuing Education for Electricians

(For All Electrical License Holders)

Part 2 - Safety

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration

OSHA Trade Release

U.S. Department of Labor
Occupational Safety and Health Administration
Office of Communications
Washington, D.C.
www.osha.gov
For Immediate Release

December 11, 2023
Contact: Office of Communications
Phone: 202-693-1999

OSHA announces switch from traditional hard hats to safety helmets to protect agency employees from head injuries better

WASHINGTON – The U.S. Department of Labor's Occupational Safety and Health Administration announced that the agency is replacing traditional hard hats used by its employees with more modern safety helmets to protect them better when they are on inspection sites.

In 2020, the Bureau of Labor Statistics reports head injuries accounted for nearly 6 percent of non-fatal occupational injuries involving days away from work. Almost half of those injuries occurred when workers came in contact with an object or equipment while about 20 percent were caused by slips, trips and falls.

Dating back to the 1960s, traditional hard hats protect the top of a worker's head but have minimal side impact protection and also lack chin straps. Without the straps, tradition hard hats can fall off a worker's head if they slip or trip, leaving them unprotected. In addition, traditional hard hats lacked vents and trapped heat inside.

On Nov. 22, 2023, OSHA published a Safety and Health Information Bulletin detailing key differences between traditional hard hats and more modern safety helmets and the advancements in design, materials and other features that help protect workers' entire heads better. Today's safety helmets may also offer face shields or goggles to protect against projectiles, dust and chemical splashes. Others offer built-in hearing protection and/or communication systems to enable clear communication in noisy environments.

The agency recommends safety helmets be used by people working at construction industry and the oil and gas industry; in high-temperature, specialized work and low-risk environments; performing tasks involving electrical work and working from heights; and when required by regulations or industry standards.

OSHA wants employers to make safety and health a core value in their workplaces and is committed to doing the same by leading by example and embracing the evolution of head protection.

Learn more about OSHA.

U.S. Department of Labor

Occupational Safety and Health Administration

Directorate of Technical Support and Emergency Management

Head Protection: Safety Helmets in the Workplace

Safety and Health Information Bulletin

SHIB 3-6-2024

Introduction

OSHA regulates head protection for general industry, construction, and maritime and requires employers to ensure affected workers wear appropriate head protection. This Safety and Health Information Bullet in (SHIB) provides information for employers and employees when selecting PPE for head protection. This SHIB also provides instructions for properly inspecting and storing head protection. With a thorough understanding of the benefits and capabilities of head protect ion options, employers and workers can make informed decisions on selection and use.

Background

Figure 1- Example of a safety helmet.

Proper head protection is crucial in work environments with falling objects, struck-by, overhead electrical hazards, and risks from slips, trips, and falls. Both scientific understanding of head injuries and head protection technology continues to advance. Modern head protection, whether it's a safety helmet or a hard hat, varies in styles and levels of protection, allowing employers and workers to choose head protect ion appropriate for the job. OSHA's head protection standards state that there can be compliance through ANSI Z89.1-2009, 2003, and 1997: published by the International Safety Equipment Association (ISEA). The range of products available today allows employers and employees to select the right type of head protection for the job, comply with the requirements of all OSHA standards (general industry, construct ion, maritime), and obtain optimum head protection.

Two Types (impact) and three Classes (electrical) of head protection are recognized.

Type I head protection offers protection from blows to the top of the head.

Type II head protection offers protection from blows to the top and sides of the head.

Class G (General) head protection is designed to reduce exposure to low voltage conductors and are proof tested at 2,200 volts (phase to ground).

Class E (Electrical) head protection is designed to reduce exposure to higher voltage conductors and are proof tested at 20,000 volts (phase to ground).

Class C (Conductive) head protection is not intended to provide protection against contact with electrical hazards.

ANSI/ISEA Z89.1-compliant head protection, including safety helmets and hard hats, are manufactured using a wide range of materials from high density polyethylene to glass reinforced nylon. Some hard hats and safety helmets incorporate advanced energy re-distribution solutions that reduce rotational forces of certain impacts and distribute impact energy throughout the headwear to help reduce brain trauma. Chin straps are recognized as an effective way to keep head protection on when working in awkward positions or when experiencing a slip or fall and should be considered for use with all head protection.

Manufactures offer an array of product-specific approved optional features designed to address specific workplace hazards. Accessories can include add-on face shields or goggles, to protect against projectiles, dust, and chemical splashes, and hearing protection and communication systems. In addition, impact indicator technology can be mounted on protective headwear for concussion awareness. However, head protection with integrated technology may not be suitable for some workplaces.

Choosing the right head protection

Employers must conduct a hazard assessment at their job site and based on the workplace hazards determine whether head protect ion is necessary and if so, the most appropriate type.

Safety Helmets for OSHA

After a general Job Hazard Analysis of its work and a thorough evaluation of head protect ion options, OSHA determined Type II, Class G safety helmets were the most appropriate form of head protection for its employees. The Agency recognizes that based on their own Job Hazard Analysis, employers and workers may decide that another form of head protection is for them.

Considerations when selecting head protection.

Construction Sites. For construction sites, especially those with high risks of falling objects and debris, impacts from equipment, awkward working positions, and/or slip, trip, and fall hazards: consider Type II head protection with chin straps.

Oil and Gas Industry. For oil and gas industry worksites where workers face multiple hazards, including potential exposure to chemicals and severe impacts: consider Type II head protection with integrated eye and face protection, like face shields and googles.

Working from Heights. For tasks or jobs that involve working from heights: consider head protection with chin straps to prevent the head protection from falling off.

Electrical Work. For tasks involving electrical work or proximity to electrical hazards, head protection with non-conductive materials (Class G and Class E) provide protection to prevent electrical shocks. NOTE – Vented hard hats or safety helmets cannot be used for electrical work.

OSHA Safety and Health Information Bulletin: Head Protection: Safety Helmets in the Workplace

High and Low-Temperature Environments. In high temperatures or where there is exposure to molten materials, employers should select head protection with advanced heat resistant properties, which can provide appropriate protect ion to workers. These are marked “HT” on the label.

For cold environments, employers should select head protect ion that has been preconditioned in low temperatures prior to testing. These are marked “LT” on the label.

High visibility. High visibility head protection is marked “HV” on the label. HV head protection helps workers be seen on jobsites like construction and road work.

Specialized Work Environments. For jobs that require integrated face shields, hearing protection or communication devices, employers should consider protective headwear that allows for these manufacturer compatible safety features.

Properly storing and evaluating head protection

Always refer to the manufacturer’s specific guidelines for head protection care, use, and storage. As a general rule:

1. Inspect the outer shell for cracks, dents, or other signs of damage. Run your fingers over the surface to check for any irregularities.

2. Examine the suspension system (headband and chin strap) for wear and tear, ensuring it is securely attached to the shell and free from damage, and inspect interior cushioning for wear or compression, if applicable. If there are any signs of deterioration, contact the manufacturer for replacement options.

3. Check for labels and certification marks. Look for labels and certification marks inside the head protection. These indicate that the head protection meets the necessary safety standards and requirements. Check that the labels are legible and not tampered with. Note: only head protection having a reverse-wearing label or mark can be worn in reverse.

4. Examine accessories and attachments. If head protect ion has manufacturer approved accessories or attachments (face shields, goggles, earmuffs, etc.), inspect them for damage or signs of wear. Make sure they are securely fastened to the head protect ion and are functioning correctly.

5. Check for proper fit. Before using head protection, ensure it fits comfortably and securely. Adjust the suspension system to achieve a snug fit without excessive pressure points. Head protection should not be too loose or too tight.

6. Refer to the manufacturer's guidelines for recommended lifespan or guidance on when to take head protection out of service. The service-life of head protection depends on many factors including storage, handling, use, and exposure to harsh environments including UV Rays. Any hard hat or helmet should be discarded when it is impacted or if there are any signs of damage or degradation.

7. Clean and dry head protection before storing. After each use, clean the exterior of head protection with mild soap and water. Ensure no dirt, debris, or chemicals are present that could compromise the

head protection's structural integrity. Once cleaned, allow the head protection to air-dry. Avoid exposing head protection to direct sunlight, extreme temperatures, or chemicals during storage. Do not store your head protection in your car or where it may be exposed to direct sunlight or extreme temperatures.

8. Impact damage. If head protection has experienced an impact or has been subjected to a significant force, retire it immediately, even if there is no visible damage. Head protection is designed for single-use impact protection and may not retain its full effectiveness after an incident.

9. Keep Records: Maintain a record of each inspection, noting the date, any findings, and actions taken. Document the date of purchase and any relevant information about the head protection to track its lifespan. This is recommended for all personal protective equipment.

Resources

OSHA's Website: The OSHA website provides extensive information on workplace safety, including head protection requirements. Workers can find OSHA standards related to personal protective equipment (PPE) and head protection.

General Industry. 29 CFR 1910.135 - Head Protection: The general requirements of this standard state that "The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects," 29 CFR 1910.135(a)(1), and that "The employer shall ensure that a protective helmet designed to reduce electrical shock hazard is worn by each such affected employee when near exposed electrical conductors which could contact the head," 29 CFR. § 1910.135(a)(2).

Construction. 29 CFR 1926.100 – Head Protection: This standard generally requires that "Employees working in areas where there is a possible danger of head injury from impact, or from falling or flying objects, or from electrical shock and burns, shall be protected by protective helmets." 29 CFR 1926.100(a).

Maritime. 29 CFR 1915.155 - Head Protection(Shipyard), 29 CFR 1917.93 – Head Protection (Marine Terminals), and 29 CFR 1918.103 – Head Protection (Longshoring): Each of the maritime standards generally require that "The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects." 29 CFR 1915.155(a)(1); 1917.93(a), 1918.103(a).

OSHA Regional and Area Offices. Employers and employees can contact their local OSHA regional or area offices for assistance and information on head protection requirements.

ANSI/ISEA Z89.1 - Industrial Head Protection: This is the ANSI standard that specifies performance and testing requirements for industrial head protection, including safety helmets and hard hats.

How to Contact OSHA

To discuss a health and safety issue at work, contact OSHA toll-free at 1-800-321-6742 (OSHA) or by email, or contact your nearest OSHA office.

This Safety and Health Information Bulletin is not a standard or regulation, and it creates no new legal obligations. The Bulletin is advisory in nature, informational in content, and is intended to assist employers in providing a safe and healthful workplace. Pursuant to the Occupational Safety and Health Act (OSH Act), employers must comply with hazard-specific safety and health standards and regulations promulgated by OSHA or by a state with an OSHA-approved State Plan. In addition, pursuant to Section 5(a)(1), the General Duty Clause of the Act, employers must provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is a recognized hazard and they do not take reasonable steps to prevent or abate the hazard. However, failure to implement any recommendations in this Safety and Health Information Bulletin is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, and the General Duty Clause.

There are 29 OSHA-approved occupational safety and health State Plans. State Plans are required to have standards and enforcement programs that are at least as effective as federal OSHA's and may have different or more stringent standards. More information about State Plans is available at: https://www.osha.gov/stateplans.

Workplace Mental Health

OSHA Occupational Safety and Health Administration

Mental health is an important component of overall well-being and is equally as vital as physical health for all employees. Mental health concerns due to work have the potential to adversely impact an employee's social interactions, productivity, performance, and absenteeism.

Stress affects people in a variety of ways such as muscle tension, headaches, stomach discomfort, high blood pressure, and heart disease. Ignoring workplace stress can have lasting harmful effects on individuals, families, co-workers, and communities.

Traumatic Events

Sometimes a shocking, scary, or dangerous experience can be so intense that it can have an emotional, cognitive, behavioral, and physical impact on a person. Some examples of traumatic events that can happen in workplaces are:

- Explosions or chemical releases
- Building, crane, or other equipment collapses
- Co-workers being injured or dying on the job
- Abuse or assault of a co-worker or client

It is normal to feel terrified during and after a traumatic event. This is part of the body's "fight or flight" response to possible danger.

Traumatic events can happen to workers in all industries.

After experiencing a traumatic event people may:

- Feel anxious, sad, or angry
- Have terrifying thoughts or flashbacks
- Have recurring nightmares
- Be confused or unable to think clearly
- Have a hard time falling and staying asleep
- Frighten easily

If these symptoms continue long after the event or affect day-to-day life, they can be signs of acute stress disorder, or post-traumatic stress disorder. Both require professional help to address.

Substance Use Disorder

Substance use disorder is a persistent desire for substances even in the face of negative consequences. Some people come to rely on opioids, stimulants, alcohol, or other substances even when the substances cause harm. People may develop a dependence on drugs, including prescription medications, and alcohol for many reasons, including the presence of other mental health conditions, chronic pain, or injuries. Regardless of the underlying reason, substance use disorder can be treated and controlled.

MAY
Mental Health Awareness Month

JUNE
Post Traumatic Stress Disorder Awareness Month

SEPTEMBER
National Suicide Prevention Month
National Recovery Month

Suicide

Suicide can touch anyone, anywhere, at any time. But it is not inevitable. Help is available.

According to the CDC[1,2]

- More than 12 million adults seriously think about suicide each year.
- More than 3 million adults make a plan to commit suicide each year.
- More than 1 million adults attempt suicide each year.
- More than 48,000 people die by suicide in the United States each year.

People of any age, gender, and background can have thoughts of suicide. Untreated mental health conditions can lead to these thoughts and even suicidal actions. That is why it is important to provide resources and encourage people to get help when they are having mental health concerns, experiencing traumatic events, or battling substance use disorders.

988 SUICIDE & CRISIS LIFELINE

Certain factors may increase an individual's risk of developing suicidal thoughts and attempting suicide such as:

- Mental health conditions like depression, bipolar disorder, schizophrenia, anxiety disorders, and substance use disorders
- Traumatic events
- Health issues like chronic pain or illness
- Prolonged stress
- Recent tragedy or loss
- Criminal or legal problems
- Job loss or financial problems
- Substance use disorder
- Childhood trauma
- Domestic violence

References

1. Centers for Disease Control and Prevention (2021)
2. Centers for Disease Control and Prevention Statistics (2021)

Resources

Employers can help change the stigma of mental health by prioritizing it as part of their workplace culture, having conversations about it, and knowing how to support those workers who say they need assistance. Workplace Stress - Overview | Occupational Safety and Health Administration (osha.gov)

- OSHA Suicide Prevention in Construction
- OSHA Workplace Stress
- Call or text 988 for free, confidential crisis counseling anytime, 24/7
- Text a counselor at 838255 for Veterans Crisis Line
- Text Talk to 741741 for English
- Text Ayuda to 741741 for Spanish

Get Help

OSHA 4395-01 2024

Long-Term Stress Harms Everyone in the Workplace

SAFE WORKPLACE GOOD HEADSPACE

Stress is not always bad. In fact, in the workplace, stress can prompt workers to stay focused on a task or meet a deadline. Extensive and prolonged stress in the workplace, however, can harm workers' physical and mental health, negatively affecting an organization's success. Employers can help alleviate workplace stress by supporting their workers. Unions and worker organizations can also support workplace mental health and well-being through their member services, outreach, and community engagement work.

How Does Long-Term Stress Harm Workers?

Physical harm:

- Heart disease
- High blood pressure
- Muscle tension and pain (e.g., back pain)
- Headaches
- Poor sleep
- Stomach discomfort
- Excessive weight gain or loss

Mental health challenges or behavioral changes:

- Depression
- Anxiety
- Burnout
- Emotional outbursts
- Social withdrawal
- Drug or alcohol use
- Restlessness
- Fatigue
- Anger and irritability
- Lack of motivation or focus

How Does Long-Term Stress Harm Employers?

- **Increases potential for workplace incidents.** Stressed and fatigued workers are less attentive in recognizing and avoiding hazards.

- **Reduces productivity.** Stressful working conditions can cause workers to lose motivation, become easily distracted, lose focus, make mistakes, experience a decline in performance, and develop mental health challenges. The World Health Organization estimates that for every dollar U.S. employers spend treating common mental health issues, they receive a return of $4 in improved health and productivity.
- **Increases absenteeism.** Exposure to long-term stress undercuts workers' physical and mental health, causing them to miss more days of work.

- **Undermines morale and leads to high turnover.** Stressed workers are less likely to be energized to perform well or to stay at a company that does not show interest in improving work conditions.

Resources

- OSHA: Worker Fatigue
- Healthy Work Campaign: Healthy Work Tools
- Mayo Clinic: Stress Management
- National Institute of Mental Health: 5 Things You Should Know About Stress
- National Institute of Mental Health: "I'm So Stressed Out!" Fact Sheet
- National Safety Council's SAFER: Mental Health and the Workplace
- NIOSH's Stress at Work booklet

Workplace Stress

Workplace Stress Menu

Workers' Rights

Overview

Statistics

- Nearly one in five US adults live with a mental illness[2].
- Workplace stress has been reported to cause 120,000 deaths in the US each year[3].
- Approximately 65% of U.S. workers surveyed have characterized work as being a very significant or somewhat significant source of stress in each year from 2019-2021[4].
- 83% of US workers suffer from work-related stress and 54% of workers report that work stress affects their home life[5].
- For every $1 spent on ordinary mental health concerns, employers see a $4 return in productivity gains

Stress can be harmful to our health and increase mental health challenges. Mental health challenges can include clinical mental illness and substance use disorders as well as other emotions like stress, grief, feeling sad and anxious, where these feelings are temporary and not part of a diagnosable condition. While there are many things in life that induce stress, work can be one of those factors. However, workplaces can also be a key place for resources, solutions, and activities designed to improve our mental health and well-being.

Workplace stress and poor mental health can negatively affect workers through[1]:

- Job performance
- Productivity

- Work engagement and communication
- Physical capability and daily functioning

Understanding the Problem

Guidance and Tips for Employers

Training Resources

Real-World Solutions

Outreach Materials

Submit Feedback

[1] Centers for Disease Control and Prevention. (July 2018). Mental Health in the Workplace.

[2] National Institute of Mental Health. (January 2022). Mental Illness.

[3] Goh, J., Pfeffer, J., & Zenios, S. A. (2015). The relationship between workplace stressors and mortality and health costs in the United States. Management Science, 62(2), 608-628.

[4] American Psychological Organization. (October 2021). Stress in America: Stress and decision-making during the pandemic.

[5] The World Health Organization (2022). Mental health in the workplace.

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration
200 Constitution Ave NW
Washington, DC 20210
1-800-321-OSHA
1-800-321-6742
www.osha.gov

Workplace Stress

Workplace Stress Menu

Workers' Rights

Understanding the Problem

Loneliness. Isolation. Uncertainty. Grief. Fear. Stress can increase these and other mental health challenges and can be harmful to our health. The amount and type of stress experienced varies from person to person due to many factors, including those experienced at work.

While there are many things in life that induce stress, work can be one of those factors. Workplace stress and poor mental health can negatively affect workers through their job performance and productivity, as well as with their engagement with others at work. It can also impact worker physical health, given that stress can be a risk factor for various cardiovascular diseases. However, workplaces can also be a key place for resources, solutions, and activities designed to improve our mental health and well-being.

Work has always presented various stress. Workers are constantly dealing with new stressors introduced to the workplace, and in some instances, these stressors have amplified other issues at work. More than 80% of US workers have reported experiencing workplace stress, and more than 50% believe their stress related to work impacts their life at home. Workplace stressors may include:

- Concerns about job security (e.g., potential lay-offs, reductions in assigned hours).
- Lack of access to the tools and equipment needed to perform work safely.
- Fear of employer retaliation
- Facing confrontation from customers, patients, co-workers, supervisors, or employers.
- Adapting to new or different workspace and schedule or work rules.
- Having to learn new or different tasks or take on more responsibilities.
- Having to work more frequent or extended shifts or being unable to take adequate breaks.
- Physically demanding work.

schooling or juggling other caregiving responsibilities while trying to work, such as caring for sick, elderly, or disabled household members.
- Concerns about work performance and productivity.
- Concerns about the safety of using public transit as a commuting option.

These, and many other, work-related stressors can take a toll on a person's sense of well-being and negatively impact their mental health. For some, these stressors can contribute to serious problems, such as the development or exacerbation of mental health challenges (e.g., anxiety disorder, depression disorder or substance use disorders.) Psychologists and psychiatrists are sounding the alarm about a mental health crisis forming, and data supporting their concerns have started to emerge. As one example, survey results from the Centers for Disease Control and Prevention (CDC) suggest that about 40 percent of U.S. adults were experiencing negative mental or behavioral health effects in June 2020, including symptoms of anxiety disorder or depressive disorder, trauma-related symptoms, new or increased substance use, or suicidal thoughts. An article published by the National Safety Council in August 2020 detailing a spike in opioid overdoses further highlights the need for more mental health resources.

Because of the many potential stressor's workers may be experiencing, a comprehensive approach is needed to address stressors throughout the community, and employers can be part of the solution. More than 85% of employees surveyed in 2021 by the American Psychological Association reported that actions from their employer would help their mental health. The goal is to find ways to alleviate or remove stressors in the workplace to the greatest extent possible, build coping and resiliency supports, and ensure that people who need help know where to turn. This toolkit offers resources and tips that employers, workers, and co-workers can use to support each other. Unions and worker organizations can also use these resources to support worker mental health.

OSHA Resources

- **Long-Term Stress Harms Everyone in the Workplace**. This fact sheet explains how workplace stress harms individual workers and employers.
- **Workplace Mental Health Fact Sheet**. This fact sheet is designed to equip workplaces with vital information and resources to address mental health concerns effectively. Available in **Spanish**.

Resources Provided by Other Organizations

- **CDC: Coping with Stress**. This webpage identifies stressors impacting the general population, provides tips to reduce stress, and links to crisis intervention services.
- **CDC: Support for Employees**. This resource identifies work-related stressors and provides stress management tips.
- **EBSA: Mental Health and Substance Use Disorder Parity**. Learn your rights about job-based mental health and substance use disorder benefits, the information your health plan must give you, and how to appeal a denied benefit claim.
- **NIOSH: Mission Possible: Measuring Worker Well-Being**. This post discusses ways employers can measure worker well-being.
- **NIOSH: Healthy Work Design and Well-Being Program**. This resource focuses on how work affects overall health and well-being, including physical, psychological, social, and economic aspects.
- **National Safety Council (NSC)::**
  - **SAFER: Mental Health and the Workplace**. This document discusses the relationship between mental health, mental illness, and the workplace; and identifies barriers preventing people from getting support.
  - **Promote Employee Mental Health and Well-being**. This resource addresses topics like mental health, stress reduction, substance misuse and more.
  - **What Employers Can do When it Comes to Mental Health**. This blogpost shares information related to new tools employers can use to improve employee well-being and how that saves company's money.
- **CDC's Mental Health Data and Statistics**. Provides resources that provide up-to-date statistics around mental health and mental illness.
- **HWC: The Healthy Work Campaign**. is a public health campaign focused on raising awareness in the U.S. about the health impacts of work stress on working people. The campaign includes a variety of resources with sections specific to employers, individual workers, and union and worker advocates.
- The Jed Foundation: **Tips for Managing Stress**. This blog provides an overview of stress and 5 ways to manage stress.

Workplace Stress

Workplace Stress Menu

Workers' Rights

Guidance and Tips for Employers

Workplaces can have many stressors. Issues in the workplace can exacerbate the risk of experiencing mental health challenges. Combined, these stressors can make it more difficult for workers to get their tasks done; threaten their productivity, happiness, and well-being; and lead to burnout. Because of the many potential stressors employees may be experiencing, a comprehensive approach is needed to address stressors throughout the community, and employers can be part of the solution. More than 85% of employees surveyed in 2021 by the American Psychological Association reported that actions from their employer would help their mental health.

The goal is to find ways to alleviate or remove stressors in the workplace to the greatest extent possible, build coping and resiliency supports, and ensure that people who need help know where to turn. Reducing workplace stress benefits everyone across an organization. It can improve morale and lead to increased productivity and better focus, fewer workplace injuries, fewer sick days, and improved physical health (e.g., lower blood pressure, stronger immune system). All these factors can also lead to reduced turnover among an employer's workforce.

In fact, the World Health Organization estimate that for every dollar U.S. employers spend treating common mental health issues, they receive a return of $4 in improved health and productivity. Employers can make a difference when it comes to helping their staff manage stress. Key things they can do include:

- **Be aware** and acknowledge that people can carry an emotional load that is unique to their own circumstances. They may be experiencing heightened levels of loneliness, isolation, uncertainty, grief, and stress; and some may face additional demands, such as

parents caring for children or elderly household members; and those with existing mental health or substance use challenges.

- **Identify factors are making it harder for workers to get their jobs done** and determine if adjustments can be made.
- **Show empathy**. Ensure workers that 1) they are not alone, 2) their employer understands the stress they are under, 3) there is no shame in feeling anxious, and 4) asking for help is important. Employers can reassure employees they are open and receptive to discussions about employees' work stress, by creating a safe and trustworthy space.
- **Provide access** to coping and resiliency resources, workplace and leave flexibilities without penalty, or other supportive networks and services. Research from the American Psychological Association suggests 50 % of employees find that a lack of paid time off or sick leave has a negative impact on stress levels at work.

The following resources provide guidance to help employers alleviate workplace stress and support mental health.

OSHA Resources

- **Getting Started Guides for Employers**. These aim to help employers gain confidence about talking to workers about workplace stress, mental health, and substance use.
  - Getting Started Guide for Senior Managers
  - Getting Started Guide for Front-line Supervisors
- **Mental Health Checklists for Employers**. These identify ways for employers to alleviate workplace stressors and support mental health.
  - Checklist for Senior Managers
  - Checklist for Front-line Supervisors
- Workplace Stress Sample Survey Questions. This document provides sample questions that employers could ask to determine whether adjustments can be made to reduce workplace stress, and if staff need mental health support.
- Myth Buster Fact Sheet. This dispels myths that might make workers reluctant to talk about workplace stress and mental health challenges. Employers could distribute this to employees or display in the workplace to reduce the stigma surrounding these topics.
- Preventing Suicides. This webpage provides information on the 988 Suicide & Crisis Lifeline, and links to access to useful resources.
- Mental Health Employer Tips – Workplace Stress Statistics (ZIP) Spanish (ZIP)
- Mental Health Employer Tips – Provide More Information (ZIP) Spanish (ZIP)
- TALK/DILO Infographic (ZIP) Spanish (ZIP)
- Start the Conversation – ABC Mental Health Videos
- Tips to Improve Relationships – ABC Mental Health Videos

- Build Your mental Health Toolkit – ABC Mental Health Videos

Resources Provided by Other Organizations

- **American Foundation for Suicide Prevention** with resources and aid to those affected by suicide, including Risk Factors and Warning Signs.
- **The Center for Construction Research and Training (CPWR) - Opioid Resources** to help prevent opioid deaths in construction.
- **Centers for Disease Control and Prevention (CDC) Suicide Prevention Webpage**, providing information on facts, risks and protective factors, prevention strategies, tips for dealing with stress, and other resources.
- **Construction Industry Alliance for Suicide Prevention (CIASP)** with resources, articles, and websites.
- **Construction Working Minds**, highlighting resources on how to address workplace suicide for workers, managers, and industry associations.
- **EBSA: Mental Health and Substance Use Disorder Parity.** Browse these tools and resources for employers who offer job-based health benefits.
- **Federal Recovery Ready Workplace Interagency Workgroup – Recovery Ready Workplace Toolkit**: Resource is designed to help businesses and other employers prevent and respond more effectively to substance misuse among employees, build their workforces through hiring of people in recovery, and develop a recovery-supportive culture.
- **HWC: The Healthy Work Campaign**. Resource includes tools that are specific to employers including a healthy work survey with recommendations
- **Suicide in the Construction Industry: Breaking the Stigma and Silence: American Society of Safety Professionals** with recommendations on how to start a conversation in the industry, and three keys for providing help.
- **U.S. Department of Labor Office of Workers' Compensation Programs - New Opioid Policy to Protect Federal Injured Workers** that provides resources to combat the opioid epidemic and reduce the potential for opioid misuse and addiction among injured federal workers.
- **U.S. Department of Veterans Affairs - Suicide Prevention** with resources for veterans and their loved ones, friends, and health care providers.
- **NIOSH Total Worker Health® Program**. This program provides a holistic approach to worker well-being to assist employers in improving the safety and health of workers.
- **NIOSH Center of Excellence: Oregon Healthy Workforce Center**. This center provides fact sheets and articles that identify actions employers can take to support

workers and alleviate their stress.

- **The National Safety Council** has provided a list of top mental health, stress reduction, and substance misuse resources, including:
  - SAFER: Stress, Emotional & Mental Health Considerations. This playbook educates leaders, supervisors, and human resources representatives about ways to ensure that workers returning to the workplace have the mental health support they need.
  - Working With Benefits Providers: Mental Health Issues Checklist. This identifies specific services that employee assistance programs and health insurance providers can offer to help workers cope with stress.
  - Training and Supporting Supervisors in Addressing Substance Use. This fact sheet speaks of the importance of being a recovery-friendly workplace.
  - Opioids At Work Employer Toolkit. This free toolkit offers materials that will help employers create recovery-friendly workplaces, including sample policies, fact sheets, posters, and videos.
  - Addressing Employee Mental Health and Distress: NSC Recommendations for Employers. This resource provides a list of recommendations and steps employers can take to support mental health in the workplace.
- **SHRM Foundation - Field Guide for Mental Health in Your Workplace**: Resource provides tools to evaluate mental health resources, inform processes for supporting mental health within an organization, and, ultimately, to help develop a strategy that demonstrates improved mental health within the workforce.
- **The American Psychiatric Association Foundation's Center for Workplace Mental Health**
  - Making the Business Case. This website shares information highlighting why investing in a mentally healthy workforce is good for your business.
  - Mental Health Topics. This webpage provides information about various mental health topics including specific disorders, warnings signs, and access to care.
- **Mental Health America**
  - Workplace Mental Health Programs. This website offers resources that employers can use to create supportive work environments and highlights a national certification program (the Bell Seal for Workplace Mental Health) that recognizes employers who stand out in this area.
  - Mental Health Resources for Employers. Resources include extensive list on mental health tips, how to integrate better practices, and how to put employees first.
- **National Alliance on Mental Illness (NAMI)**

- The Mental Health Movement in the Workplace. This blog entry discusses the benefits of addressing mental health in the workplace and lists actions that employers can take to do so.
- The Ultimate Workplace Mental Health Toolkit. This document, produced by NAMI's Chicago affiliate, provides a primer for employers on mental health, stigma, stress and toxic stress, and burnout. It also outlines the components of an overall approach that employers can take to promote worker well-being and offers several tools (e.g., checklists, surveys, conversation planners) to help them achieve success.

- **American Psychological Association**
  - Supporting Employee Mental Health When Reopening the Workplace
    This article offers suggestions on ways that employers can make the transition back to onsite work easier after working remotely for a lengthy period of time.
  - Stress Management for Leaders Responding to a Crisis
    This fact sheet offers tips for leaders (e.g., supervisors, managers) to help them handle their internal stressors so they can lead effectively.
  - Striving for Mental Health in the Workplace Guide. This resource shares tips on how to shift workplace culture to address mental health stigma and support employee well-being.
- **The U.S. Department of Veterans Affairs**
  - For Leaders: Helping Employees in the Aftermath of Loss. This document explains what employers can do to support grieving staff.

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration
200 Constitution Ave NW
Washington, DC 20210

Workplace Stress

Training Resources

The idea of talking about stress and mental health at work might feel scary or too personal. These can be sensitive topics that require a foundation of trust and goodwill to broach, or alternatively, the support for a worker to seek external resources and assistance outside of the workplace.

However, there are ways in which employers, supervisors, and co-workers can support each other, and training is available on a variety of relevant topics. Ideally, employers should provide training for supervisors and workers to help them recognize the signs and symptoms of stress. Through this training, Employers, supervisors, and workers will know what to say, how to listen, and how to support others at the workplace who are struggling; learn about ways to build coping and resiliency skills; and know what avenues are available if professional help is needed either for themselves or their co-workers. Unions and worker organizations can also serve an important role in supporting workplace mental health and well-being through their member services as well as their outreach and community engagement work.

These training resources offer useful starting points for employers, supervisors, and employees:

- The National Council for Mental Wellbeing offers Mental Health First Aid, which teaches people how to identify, understand and respond to signs of mental illness and substance use disorders. Multiple trainings are offered (some of which are virtual), and they target different areas (e.g., workplace in general, fire and EMS sector). Train-the-trainer programs are offered for employers that wish to have a staff member become a qualified trainer and then provide training more broadly throughout the organization. Additionally, companies

insight on how to **question (Q)**, **persuade (P)**, and **refer (R)** someone who may be suicidal.

- The U.S. Department of Veterans Affairs offers a Stress First Aid slide deck, which is a 30-minute presentation (developed for first responders) that provides a framework to improve recovery from stress reactions.

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration
200 Constitution Ave NW
Washington, DC 20210
1-800-321-OSHA
1-800-321-6742
www.osha.gov

Workplace Stress

Workplace Stress Menu

Workers' Rights

Real World Solutions

There's no one-size-fits-all strategy when it comes to alleviating workplace stress. The most effective approach is to identify the specific stressors associated with a particular job or industry and take concrete and practical steps to remove or lessen those stressors. Much can be learned by exploring what others are already doing and tips experts in the field have identified to address workplace stress. Some of the approaches discussed below can be applied to any workplace; others focus on specific groups, such as hybrid and remote workers, working parents and other caregivers, young workers, frontline workers, those in customer service roles, and workers who do manual labor, among other workers.

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration
200 Constitution Ave NW
Washington, DC 20210

Workplace Stress

Workplace Stress Menu

Workers' Rights

Outreach Materials

It is imperative to talk about mental health; shine light on the stressors; strategize about ways to alleviate stress them; and be on the lookout for signs and symptoms of stress and mental health emergencies so that people can either direct themselves, their friends, co-workers or family members to helpful coping and resiliency resources or other supportive networks and services if needed. The key is to build awareness, and the outreach products identified below will help with that goal. Workers and employers alike will benefit from the information, and the latter may wish to use these resources as building blocks for creating an awareness campaign within their organization. Employers, unions, and worker organizations can and should take all steps to protect the mental health of workers. Unions and worker organizations can also serve an important role in supporting workplace mental health and well-being through their member services as well as their outreach and community engagement work.

OSHA Resources

- **Support One Another Toolkit** (ZIP) Spanish (ZIP). Provides tips on creating a workplace culture that support mental health by talking about mental health.
- **Working Together poster**. Provides a brief overview of steps employers and workers can take to address stress and mental health in the workplace.
- **Supporting Your Co-Workers poster**. Provides concrete tips that people can use to support their co-workers, offering suggestions on how to be respectful when broaching stress and mental health topics, how to listen compassionately, how to determine if more assistance is needed, and how to follow up on concerns.
- **Worker-Fatigue Webpage**. Focuses on worker fatigue and includes information about the impact of demanding work schedules and measures workers and employers can take to

and co-workers can help each other address stress and mental health, and advice for those currently facing mental health challenges.

Resources Provided by Other Organizations

- **CDC Foundation: How Right Now**. Interactive site was created to support mental health. It asks users how they are feeling (e.g., stressed, afraid, grieving, lonely) and then directs them to a variety of stress relief tools and mental health supports.
- **EBSA: Mental Health and Substance Use Disorder Parity.** Learn about your job-based mental health and substance use disorder rights and get assistance from a live Benefits Advisor.
- **HHS: 5 Things About Staying Mentally Healthy**. Two-minute video that offers five tips for coping with the mental strain: 1) avoiding alcohol and drugs as a coping mechanism, 2) staying active, 3) exploring wellness programs, 4) staying connected, and 5) seeking help if needed.
- **The U.S. Department of Veterans Affairs' Free Mobile App: Mindfulness Coach**. Walks users through mindfulness meditation to help reduce stress and cope with unpleasant emotions.
- **SAMHSA: Your Recovery is Important: Virtual Recovery Resources**. Tip sheet that identifies virtual resources that people can use to support their recovery from mental health/substance use disorders.
- **SAMHSA: Decisions in Recovery: Treatment for Opioid Use Disorder**. Offers a variety of resources to support recovery and treatment for those who are ready to address their opioid use.
- **NIOSH Science Blog: Improve Sleep: Tips to Improve Your Sleep When Times Are Tough**. Blogpost that emphasizes the importance of high-quality sleep during stressful times and offers evidence-based suggestions on how to improve it.
- **Mental Health America**
  - Workplace Mental Health Programs. This website offers resources that employers can use to create supportive work environments and highlights a national certification program (the Bell Seal for Workplace Mental Health) that recognizes employers who stand out in this area.
  - Mental Health Resources for Employers. Resource includes extensive list on mental health tips, how to integrate better practices, and how to put employees

mental health condition (e.g., anxiety, depression, addiction, eating disorders).

- **American Psychological Association: Psychologists' Advice for Newly Remote Workers**. Article with tips for remote workers to reduce stressors and prevent isolation, advising them to minimize distractions, set goals and boundaries, make a communication plan, and seek social connections.
- **The National Institute of Mental Health: My Mental Health: Do I Need Help?** Poster that differentiates between mild and severe symptoms, identifies self-care techniques, and explains how to seek professional help.
- **Existing Mental Health Campaigns and Toolkits:**
  - Healthy Work Campaign
  - National Prevention Week
  - Mental Health Awareness Month
  - Suicide Prevention Month
  - List of Awareness Events
  - Mental Health Awareness Charity Walks and Runs
  - Opioids At Work Employer Toolkit
  - The ICU program, which stands for Identifying, Connecting, and Understanding, as well as "I See You."
  - Right Direction
  - Mental Health in Rural Communities Toolkit
  - Upper Midwest Agricultural Health and Safety Center: Stress and Mental Health
  - National Center for Farmworker Health Resource Hub
- **The Jed Foundation**
  - How to Practice Gratitude. This blog provides an overview of gratitude and how it can strengthen our mental health, including gratitude exercises that can help you practice it in your daily life.
  - How to Relieve Stress: Breathing Exercises You Can Do Anywhere: This blog provides an overview of the importance of breathing during stressful events. The blog provides examples of breathing exercises that anyone can do anywhere and anytime to relieve stress.

Scroll to Top

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration
200 Constitution Ave NW
Washington, DC 20210
1-800-321-OSHA
1-800-321-6742
www.osha.gov

FEDERAL GOVERNMENT⊞

White House
Benefits.gov
Coronavirus Resources
Disaster Recovery Assistance
DisasterAssistance.gov
USA.gov
Notification of EEO Violations
No Fear Act Data
U.S. Office of Special Counsel

OCCUPATIONAL SAFETY & HEALTH⊞

Frequently Asked Questions
A - Z Index
Freedom of Information Act - OSHA
Read The OSHA Newsletter
Subscribe to the OSHA Newsletter
OSHA Publications
Office of Inspector General

ABOUT THE SITE⊞

Freedom of Information Act
Disclaimers

Submit Feedback

2025 Continuing Education for Electricians

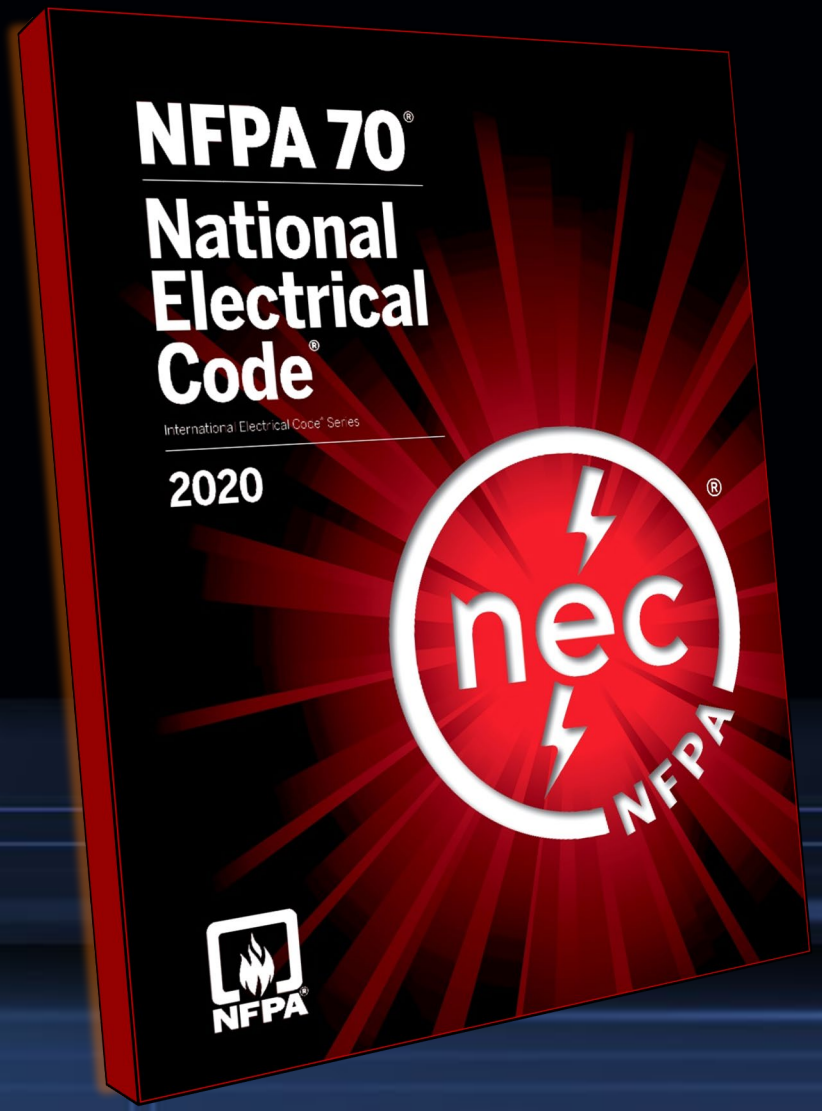
(For C5, C6, C7, C8, L1, L2, L5, L6, PV1, PV2, T1, and T2 License Holders)

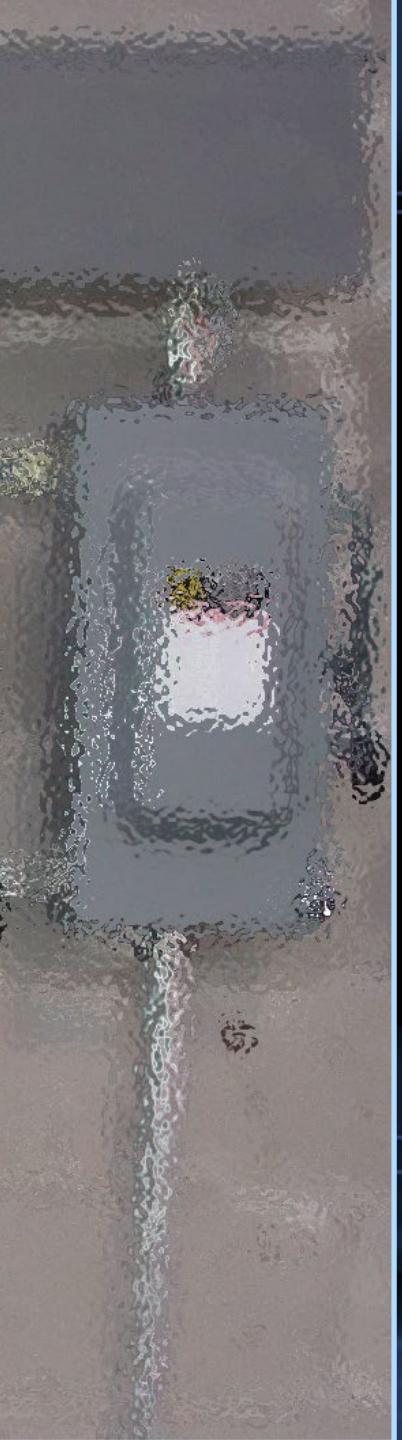
Part 3 – 2020 National Electrical Code

2025 Limited License Types Including:

C-5, C-6, C-7, C-8, L-1, L-2, L-5, L-6, PV1, PV2, T-1, T-2

Analysis of Changes-2020 *NEC*





Chapter One
General

Article 100: Definitions – Free Air

- **Free Air (as applied to conductors)**. Open or ventilated environment that allows for heat dissipation and air flow around an installed conductor. (CMP-6)
- New definition for “Free Air (as applied to conductors)” added to Article 100
- The term “free air” is used throughout the *NEC*, yet to this point, this term has not been defined in the *NEC*
- Contact or close proximity with additional conductors or other materials that could impede the flow of heat away from the conductor would not allow the use of free air ampacity ratings of the conductor ampacity tables in Article 310

Article 100 Labeled

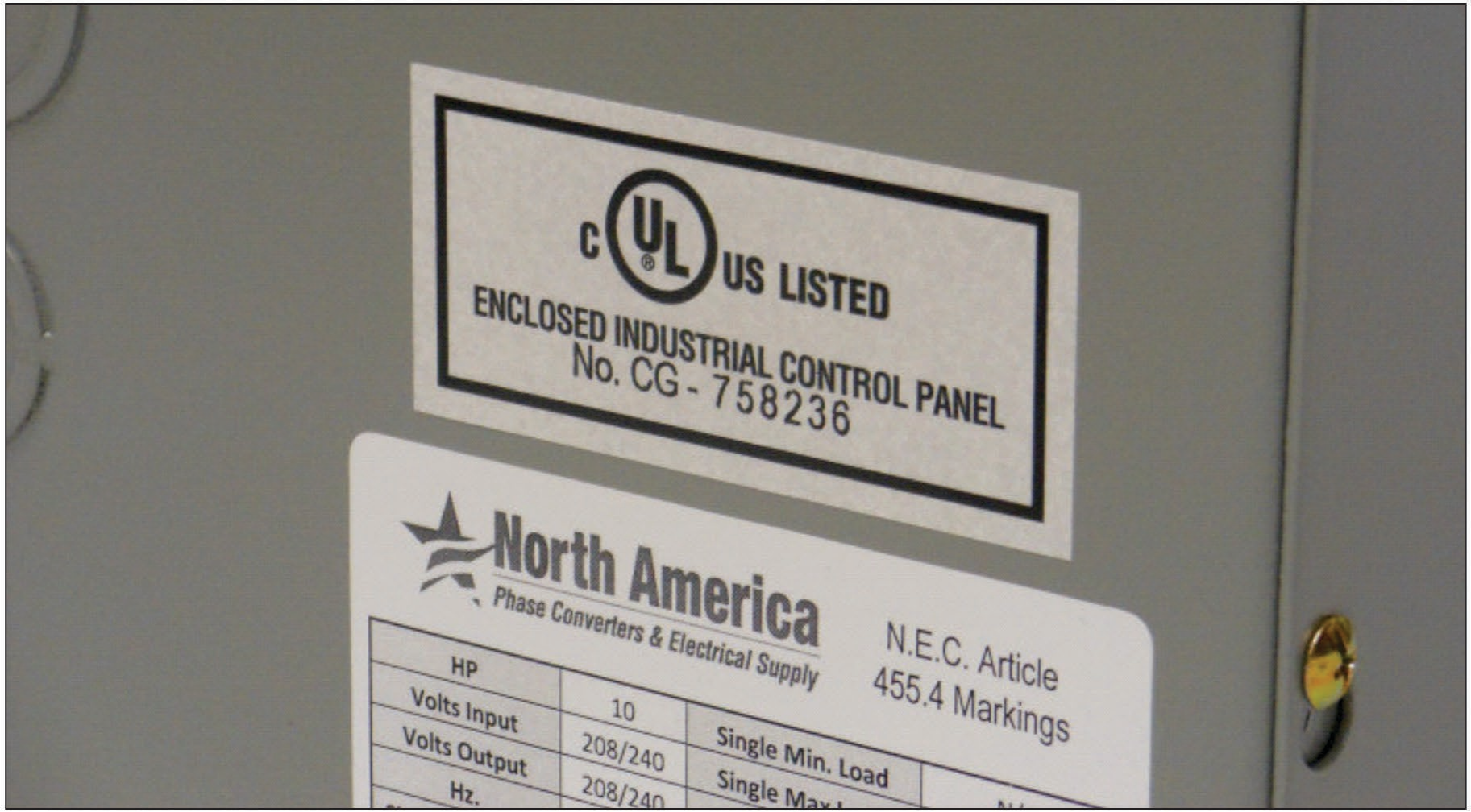
- New Informational Note added explaining that even though a section of the *NEC* may require a product to be labeled, it is common practice to have the label, symbol, or other identifying mark applied to the **smallest unit container** in which the product is packaged
- Several types of electrical equipment addressed in the *NEC* that are required to not only be "**Listed**," but also required to be "**Labeled**"
- A typical pressure wire connector (wire nut) for splicing conductors together is required to be listed and labeled, but it is one of those products that are too small to affix a label to each individual pressure wire connector

Article 100 Definitions: Free Air (as Applied to Conductors)

Free Air (as applied to conductors). Open or ventilated environment that allows for heat dissipation and air flow around an installed conductor. (CMP-6)

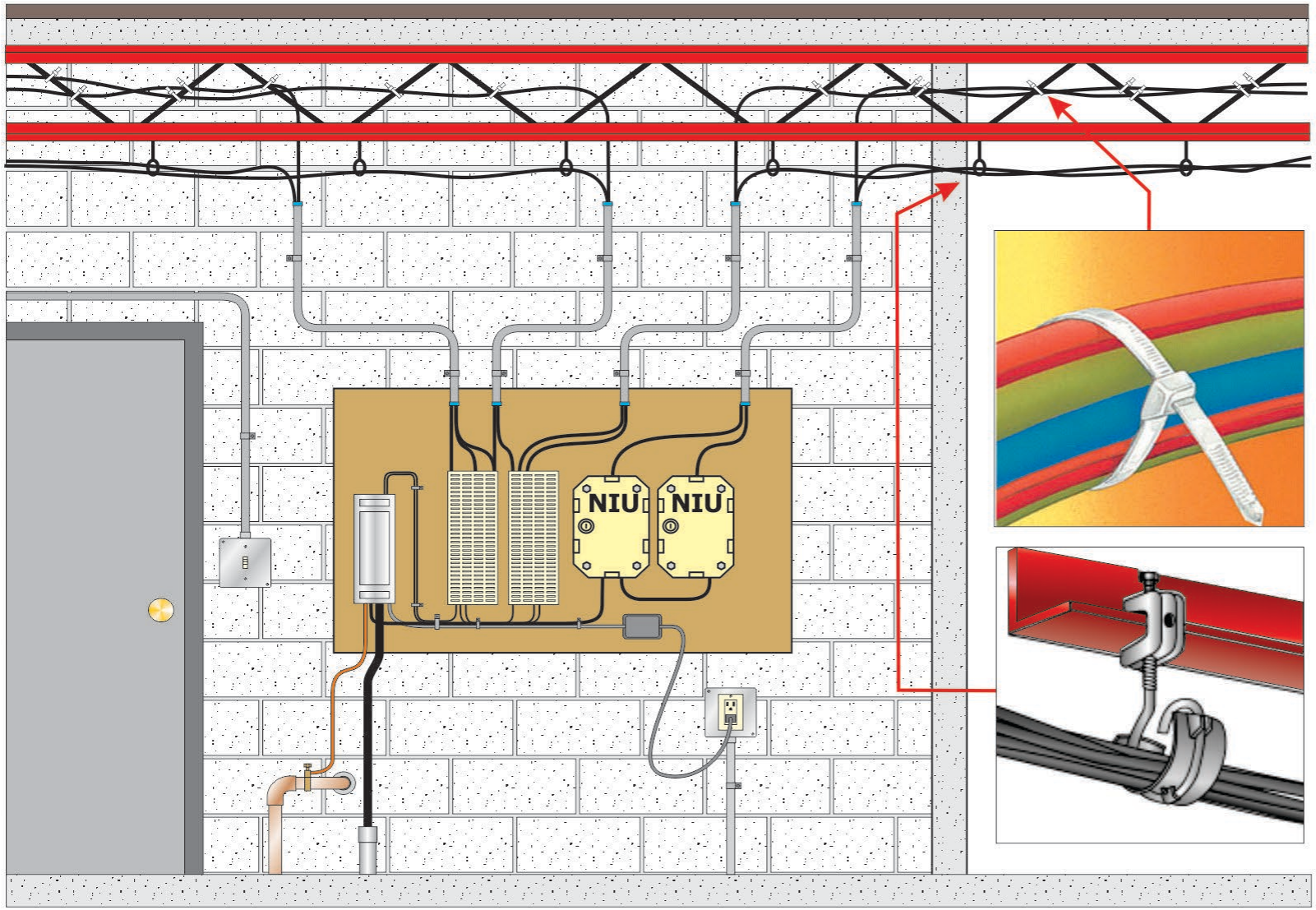
New definition should clarify that contact or close proximity with additional conductors or other materials that could impede the flow of heat away from the conductor would not allow the use of free air ampacity ratings of the conductor ampacity tables in Article 310

110.3(B) Installation and Use of Listed Equipment



Equipment that is listed, labeled, or both shall be installed and used in accordance with any instructions included in the listing or labeling

110.12(C) Mechanical Execution of Work (Cables and Conductors)

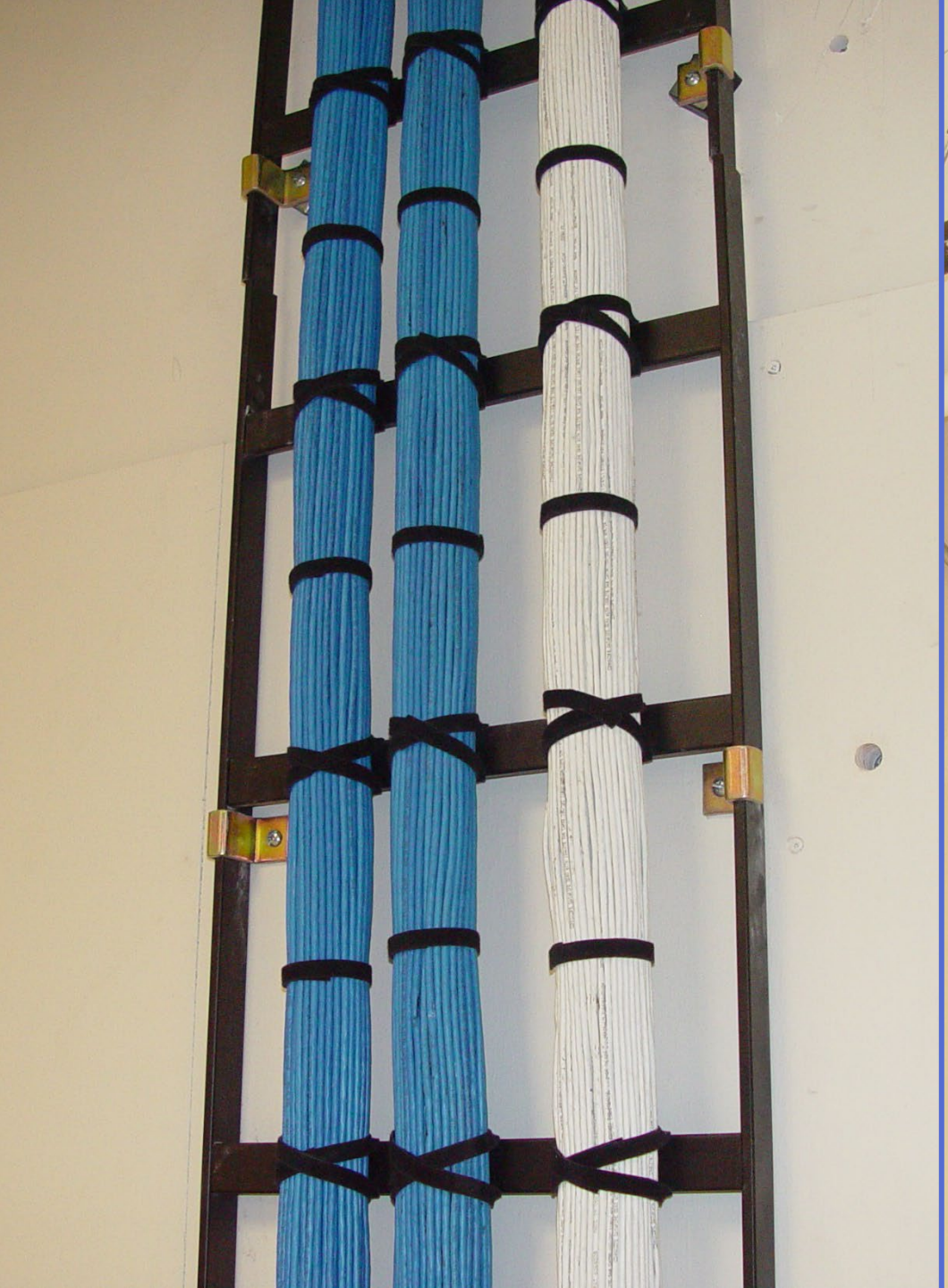


Exposed cables and conductors to be supported by building structure to prevent damaged by normal building use

Cables and conductors to be secured by hard-ware *(straps, staples, cable ties, hangers, etc.)* designed and installed to not damage the cable

Installation to comply with 300.4 and 300.11

Nonmetallic cable ties and other nonmetallic cable accessories used to secure and support cables in environmental air spaces (plenums) must be listed as having low smoke and heat release properties

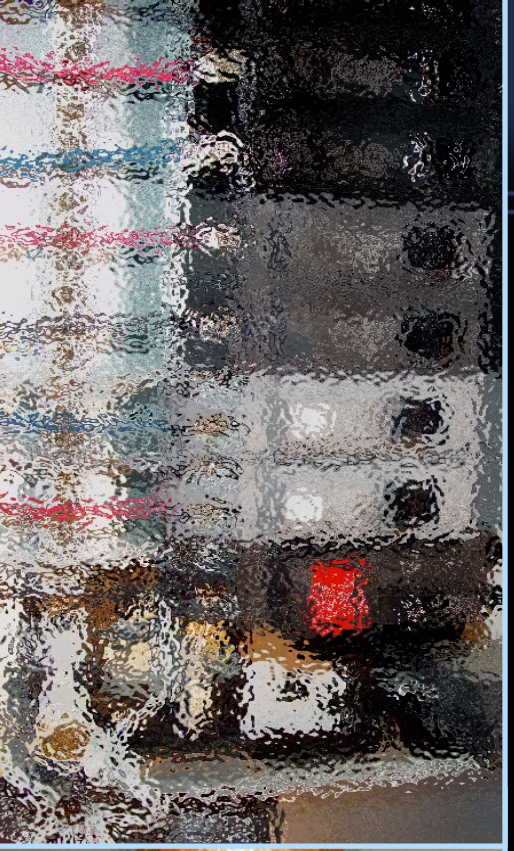


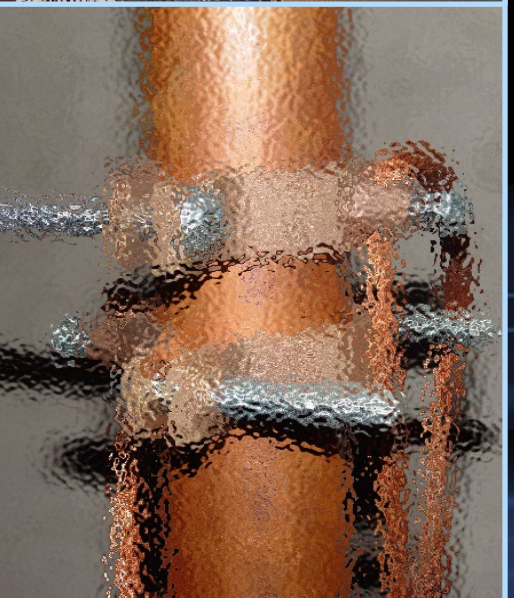
110.3(B) Installation and Use of Listed Equipment

- Equipment that is listed, labeled, **or both** shall be installed and used in accordance with any instructions included in the listing or labeling
- Listing requirements were **modified** for clarity and usability to address equipment that is listed, labeled, **or both**
- The words “listed” and “labeled” are often looked upon as interchangeable by installers and inspectors alike even though both of these terms are defined in Article 100
- Electrical equipment can easily be both listed and labeled
- Marking on the product is the manufacturer’s substantiation that the product is in compliance with the appropriate product standard
- Only true way AHJ can determine whether the inspected product is compliant with the applicable product standard is the third-party label on the product

110.12(C) Cables and Conductors

- Redundant requirements for "**Mechanical Execution of Work**" for communication cables and conductors in Chapter 7 and 8 were relocated to Article 110
- A new subdivision (C) titled "**Cables and Conductors**" has been added to 110.12 which is titled "**Mechanical Execution of Work**"
- Includes relocated requirements from the **.24 sections** from the communications articles in Chapters 7 and 8
- Conductor and cable support and concerns about damage are addressed in both 110.12(C) and in 800.24



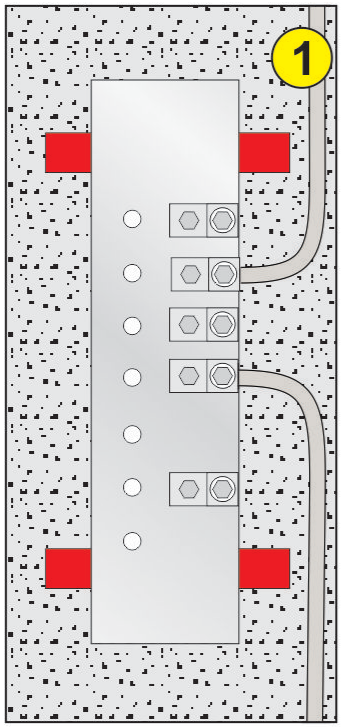


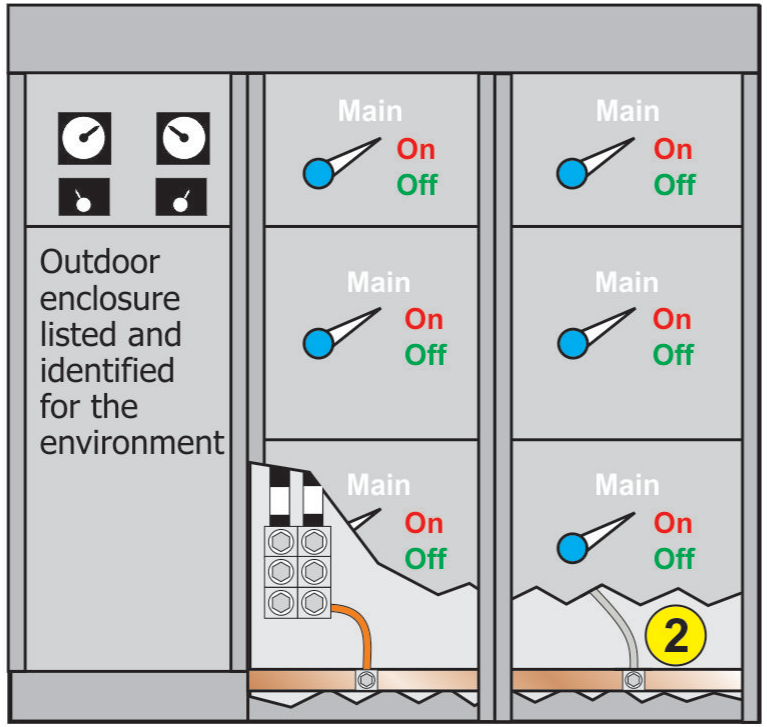
Chapter Two Wiring and Protection

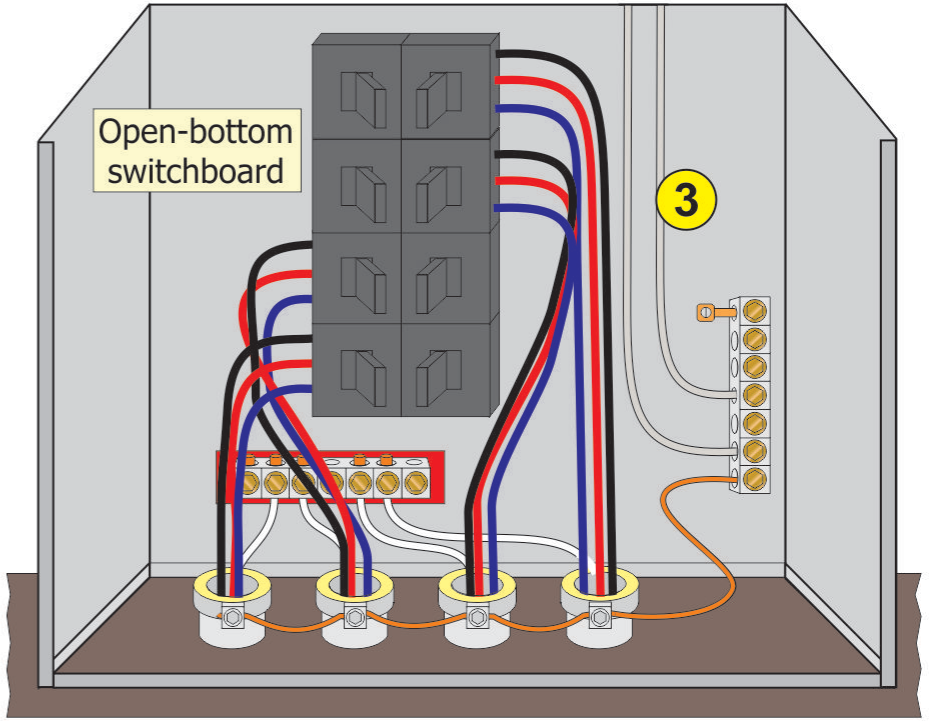
250.64(A) Aluminum or Copper-Clad Aluminum GECs

- 250.64(A) formatted into a **list format** for improved clarity and usability
- Clarifies that terminations for **aluminum or copper-clad aluminum** grounding electrode conductors (GEC) located in the **interior of equipment "listed and identified for the environment"** are separated from the earth and **can be terminated** within 450 mm (18 in.) of the earth
- Section was divided into **three distinctive parts** to better distinguish what type of bare, covered, or insulated aluminum or copper-clad aluminum GECs can or cannot be terminated **within 450 mm (18 in.) of the earth**, or be installed **where subject to corrosive conditions**, or be installed **in direct contact with concrete**
- Similar changes occurred at **250.120(B)** for terminating aluminum or copper-clad aluminum EGCs within 450 mm (18 in.) of the earth

250.64(A) Aluminum or Copper-Clad Aluminum GECs







Grounding electrode conductors (GEC) of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

1. Bare or covered GECs ***not permitted*** to be installed where subject to corrosive conditions or be installed in direct contact with concrete *(without an extruded polymeric covering)*
2. Terminations made within outdoor enclosures that are listed and identified for the environment are ***permitted*** within 450 mm (18 in.) of bottom of the enclosure
3. Aluminum or copper-clad aluminum GECs installed external to buildings or equipment enclosures ***not permitted*** to be terminated within 450 mm (18 in.) of the earth

250.64(B)(2) and (B)(3) GEC Installations Exposed to Physical Damage

- Revision clarifies that **Schedule 80 PVC** is required when PVC conduit is used for **protection from physical damage** for a grounding electrode conductor (GEC)
- This is **consistent with other sections of the *Code***, such as 230.50(B)(1) where Schedule 80 PVC is an option to provide protection from physical damage for service-entrance conductors
- Schedule 40 PVC does not provide the **impact and crush resistant characteristics** required for providing the protection anticipated by the *Code* and cannot be used in any location where protection from physical damage is required

Required to be Schedule 80 PVC

(if deemed necessary due to possible physical damage)

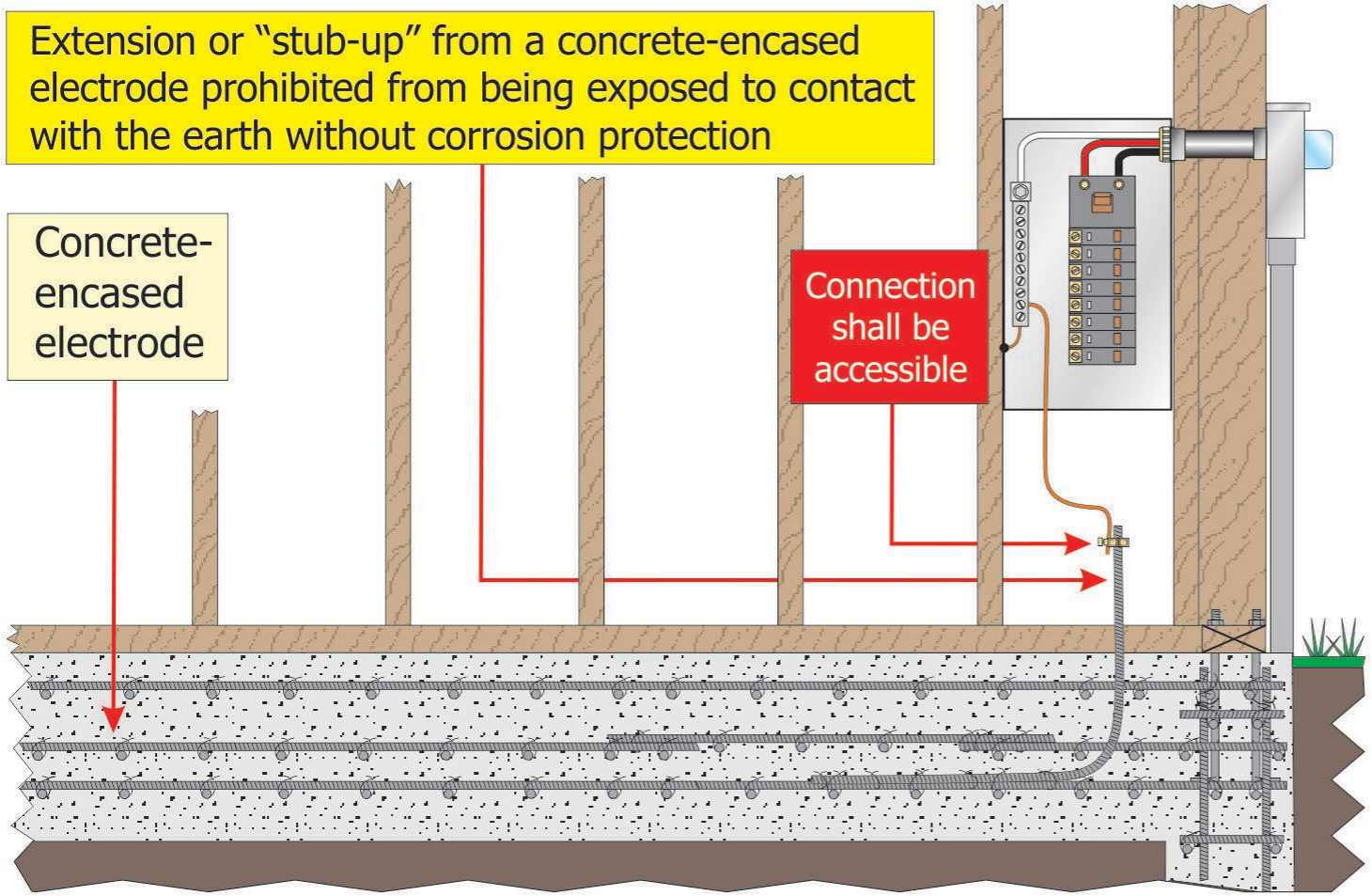
250.68(C)(3) GEC Connections to Rebar-Type Concrete-Encased Electrodes

- New provisions added to clarify that the rebar system in a footing or foundation is not suitable as the conductor to interconnect other grounding electrodes
- 250.68(C)(3), which gives the permission to use a rebar extension for connection of GECs and bonding jumpers was reformatted into a **list format**
- **Installation requirements** for the use of a rebar “stub-up” as an extension connected to a concrete-encased electrode was added
- Rebar extension must be continuous with the concrete-encased electrode rebar or it needs to be connected to the concrete-encased electrode rebar by the usual steel tie wires, exothermic welding, welding, or other effective means

250.68(C)(3) GEC Connections to Rebar-Type Concrete-Encased Electrodes *(cont.)*

- Additional language **prohibits** the rebar *(both the concrete-encased electrode rebar and the rebar extension)* from being used as a conductor to **interconnect the individual electrodes** of grounding electrode systems
- The rebar extension:
  - Must be **connected to the rebar** in the foundation or footing
  - Shall not be exposed to earth contact without **corrosion protection**
  - Shall not be used to **interconnect electrodes** of the grounding electrode system
- Same change added at **250.53(C)** for bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system

250.68(C)(3) Concrete-Encased Electrode Extension



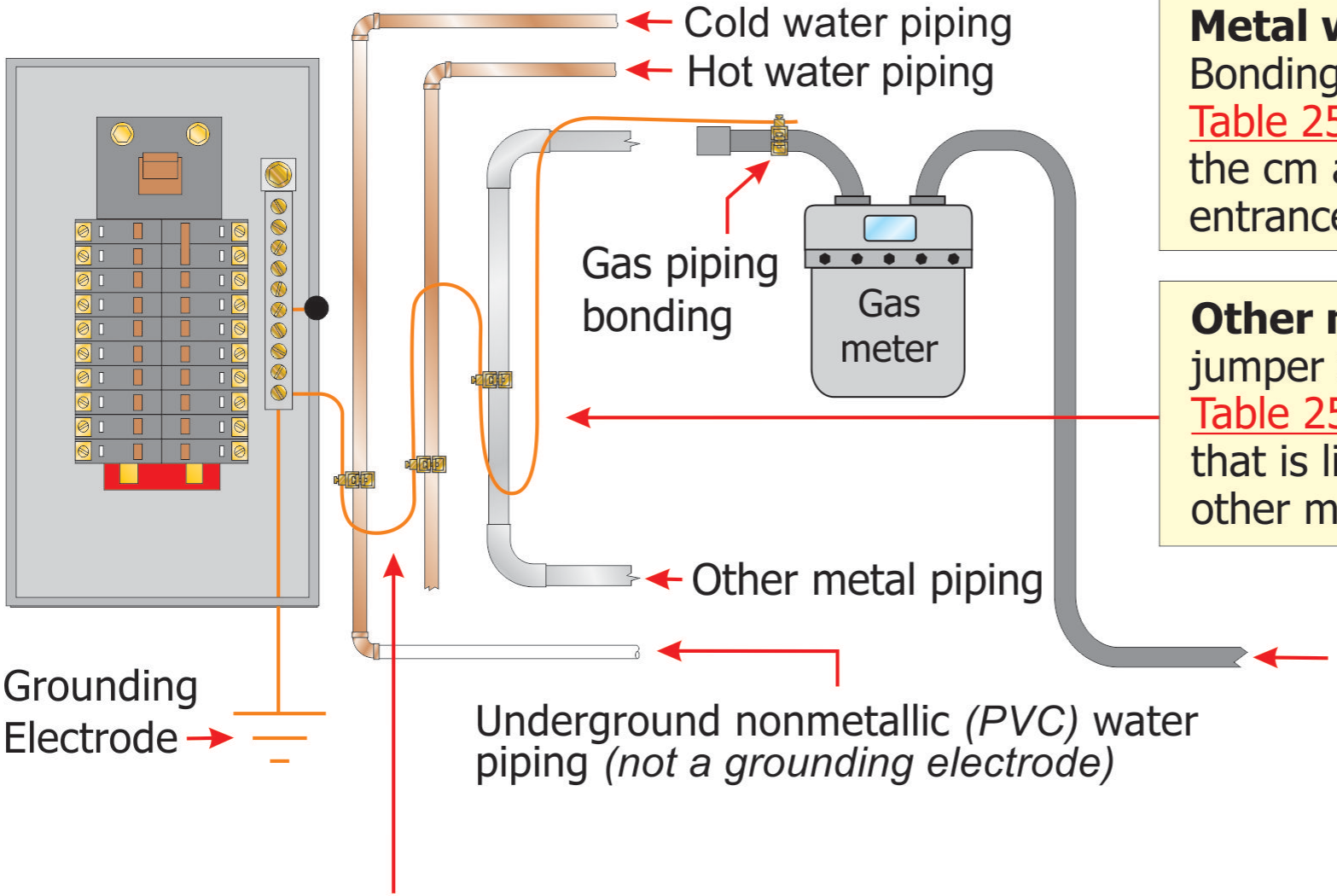
Rebar extension must be continuous with the concrete-encased electrode rebar or needs to be connected to the concrete-encased electrode rebar by the usual steel tie wires, exothermic welding, welding, or other effective means

Rebar *(both the concrete-encased electrode rebar and the rebar extension)* not permitted to be used as a conductor to interconnect the individual electrodes of grounding electrode systems

250.104(A)(1) Bonding of Metal Water Piping Systems

- Revision clarifies that **bonding jumper(s)** used to bond metal water piping system(s) together are not required to be larger than **3/0 copper** or **250 kcmil aluminum or copper-clad aluminum**
- Bonding jumper(s) used to bond metal water piping together still required to be sized based on **Table 250.102(C)(1)** but not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum
- Changes made as a result of changing sizing reference from Table 250.66 to Table 250.102(C)(1) in the 2017 *NEC*, which resulted in an **inadvertent increase in the sizing** of bonding jumper(s) for metal water piping systems
- Same basic change occurred at **250.104(C)** for bonding of **structural metal**

250.104(A)(1) Bonding of Metal Water Piping Systems



Metal water piping system: Bonding jumper to be sized per Table 250.102(C)(1) based on the cm area of the service-entrance conductors

Other metal piping: Bonding jumper to be sized based on Table 250.122 for the circuit that is likely to energize the other metal piping system(s)

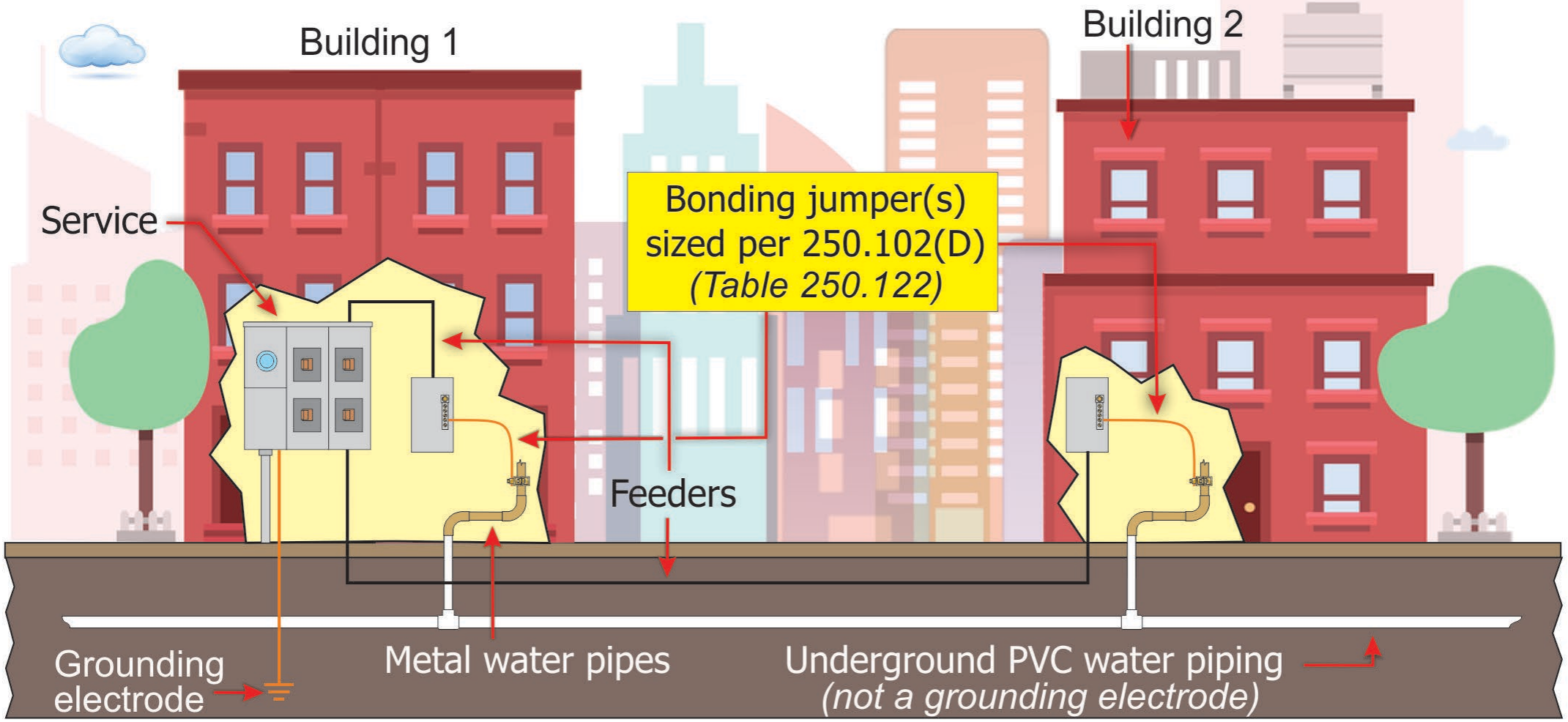
Bonding jumper(s) used to bond metal water piping together required to be sized based on Table 250.102(C)(1), but not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum

250.104(A)(3) Buildings or Structures Supplied by Feeder(s) or Branch Circuit(s)

- Revision clarifies the **sizing requirements for bonding jumper(s)** used for bonding metal water piping systems when a building or structure is supplied by a feeder or branch circuit
- Reference changed from Table 250.102(C)(1) to **250.102(D)** *(and **Table 250.122**)* based on the largest overcurrent device supplying circuits the building or structure
- This bonding jumper sizing was changed in 2017 *NEC* to required sizing in accordance with Table 250.102(C)(1), based on the size of the feeder or branch-circuit conductors that supply the building or structure
- Feeders and branch circuits are protected by overcurrent protective devices and the size of these bonding jumpers should be based on 250.122

250.104(A)(3) Buildings or Structures Supplied by Feeder or BC

Bonding jumper(s) used for bonding metal water piping system(s) at multiple buildings or structures supplied by a feeder(s) or branch circuit(s) required to be sized based on 250.102(D) *(Table 250.122)* based on the largest overcurrent device supplying circuits to the buildings or structures



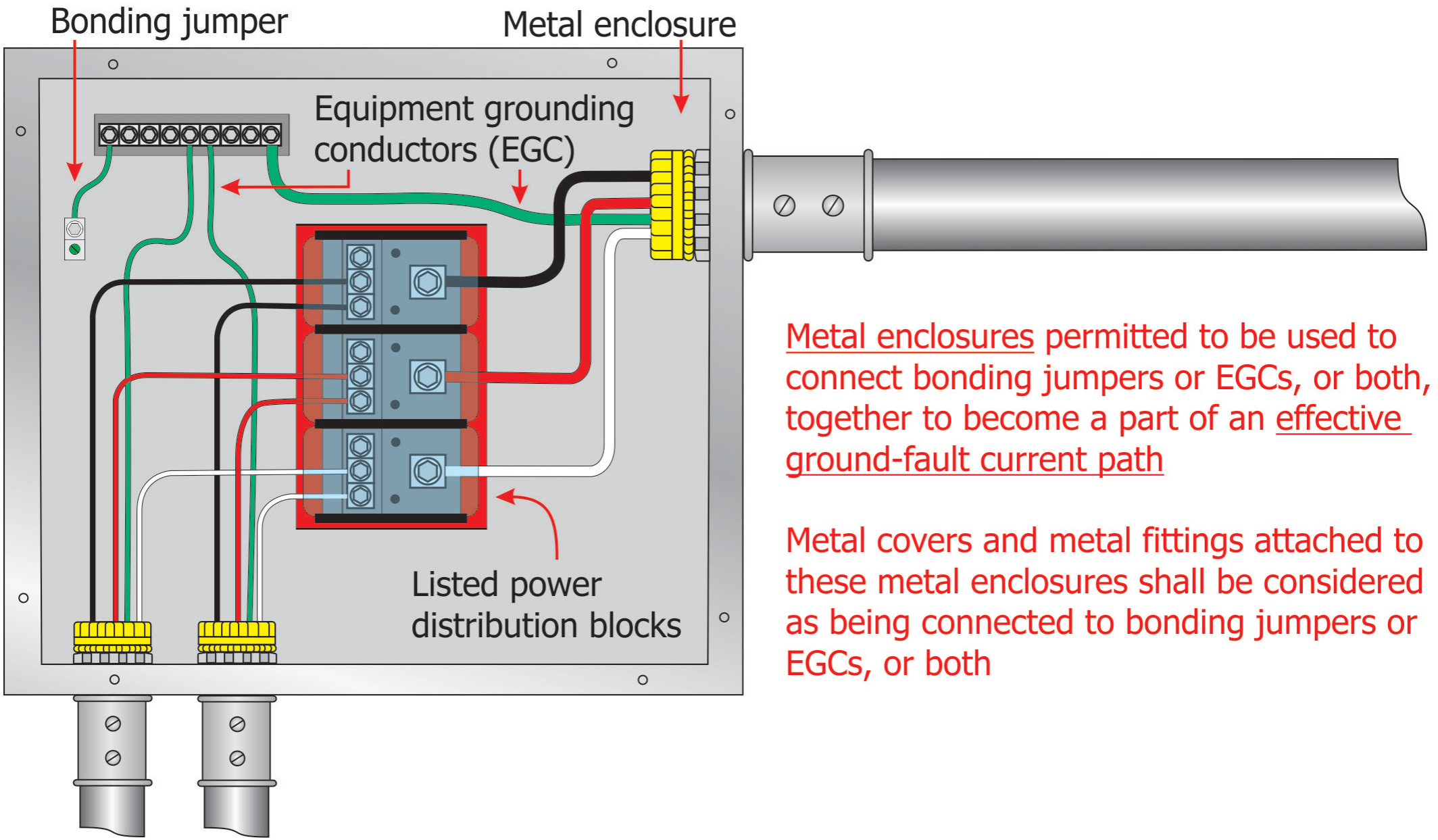
250.109 Metal Enclosures

- New section added indicating **metal enclosures** can be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an **effective ground-fault current path**
- Metal covers and metal fittings attached to these metal enclosures are also considered to be connected to the enclosed bonding jumpers or equipment grounding conductors, or both
- If circuit conductors are spliced within a box or terminated on equipment within or supported by a box, all EGCs associated with any of those circuit conductors are **required to be connected within the box or to the box** [250.148]
- Exposed, normally non-current-carrying metal parts of fixed equipment supplied by or enclosing conductors or components that are likely to become energized are **required to be connected to an EGC** [250.110]

250.109 Metal Enclosures *(cont.)*

- New section added indicating **metal enclosures** can be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an **effective ground-fault current path** *(cont.)*
- These and other *Code* requirements call for a connection of EGCs to metal box or metal enclosure, yet there was **no *Code* allowances** for these metal enclosures to serve as any part of an effective ground-fault current path
- Needed change to clarify that metal boxes, cabinets and other metal enclosures are **permitted to be used for grounding and bonding** of metal raceways, metal cables, and other metal equipment that is connected to the metal box, cabinet or enclosure

250.109 Metal Enclosures as an Effective Ground-Fault Path



Metal enclosures permitted to be used to connect bonding jumpers or EGCs, or both, together to become a part of an effective ground-fault current path

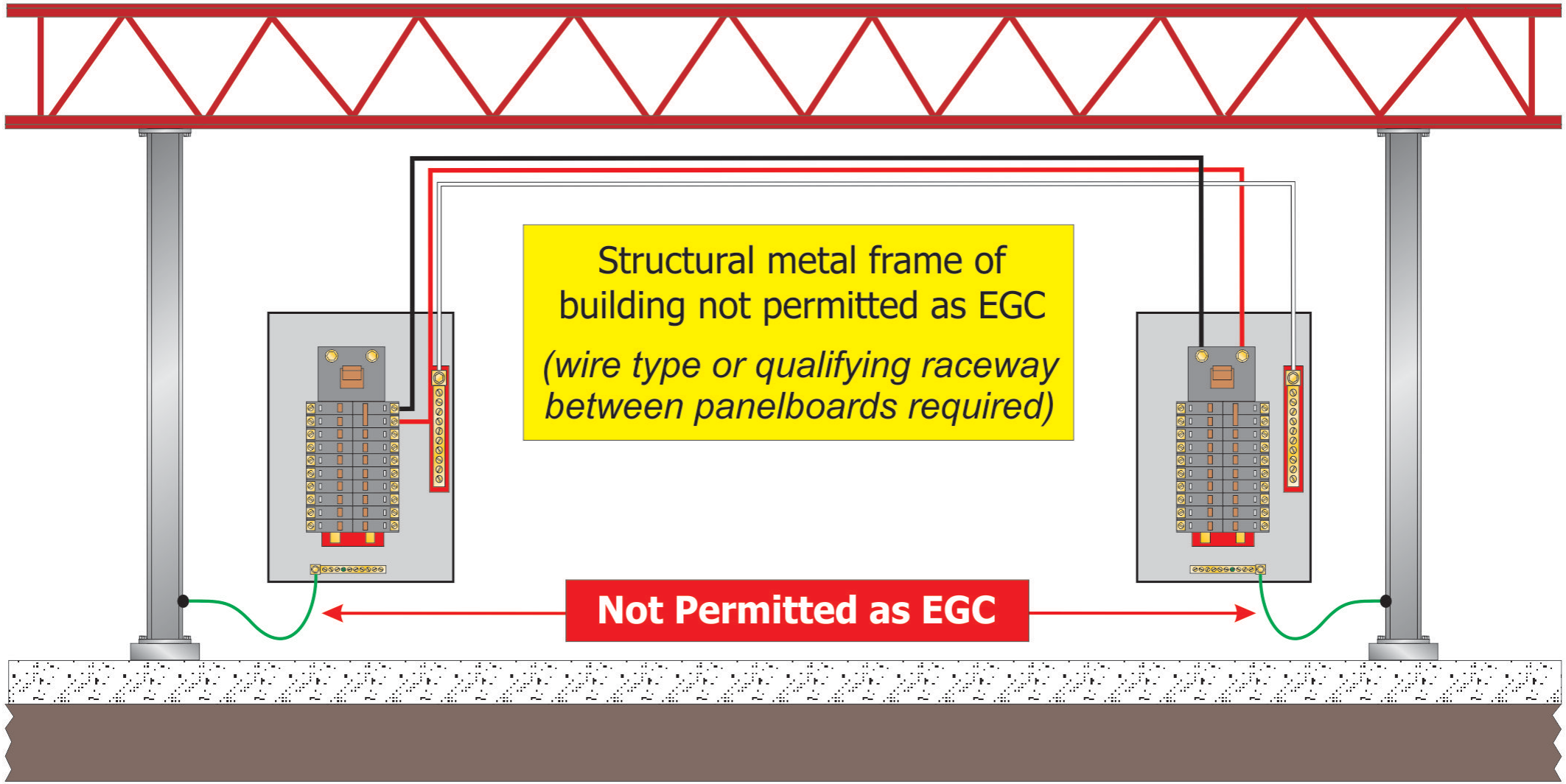
Metal covers and metal fittings attached to these metal enclosures shall be considered as being connected to bonding jumpers or EGCs, or both

250.121(B) Restricted Use of Metal Frame of Building or Structure as EGC

- New sub-section added to prohibit the **structural metal frame of a building or structure** from being used as an **equipment grounding conductor** (EGC)
- These prohibitive EGC rules were previously found at 250.134(A) and only applied to electrical equipment secured to and in electrical contact with a metal rack or structure provided for the electrical equipment's support
- New rules apply to **all types** of equipment *(not just electrical equipment supported by a metal rack or structure)* and structural metal frames of a building or structure
- The structural metal frame of a building or structure need not serve as an EGC due to the uncertain path that ground-fault current must take in an effort to clear a fault

250.121(B) Restricted Use of Metal Frame of Building or Structure

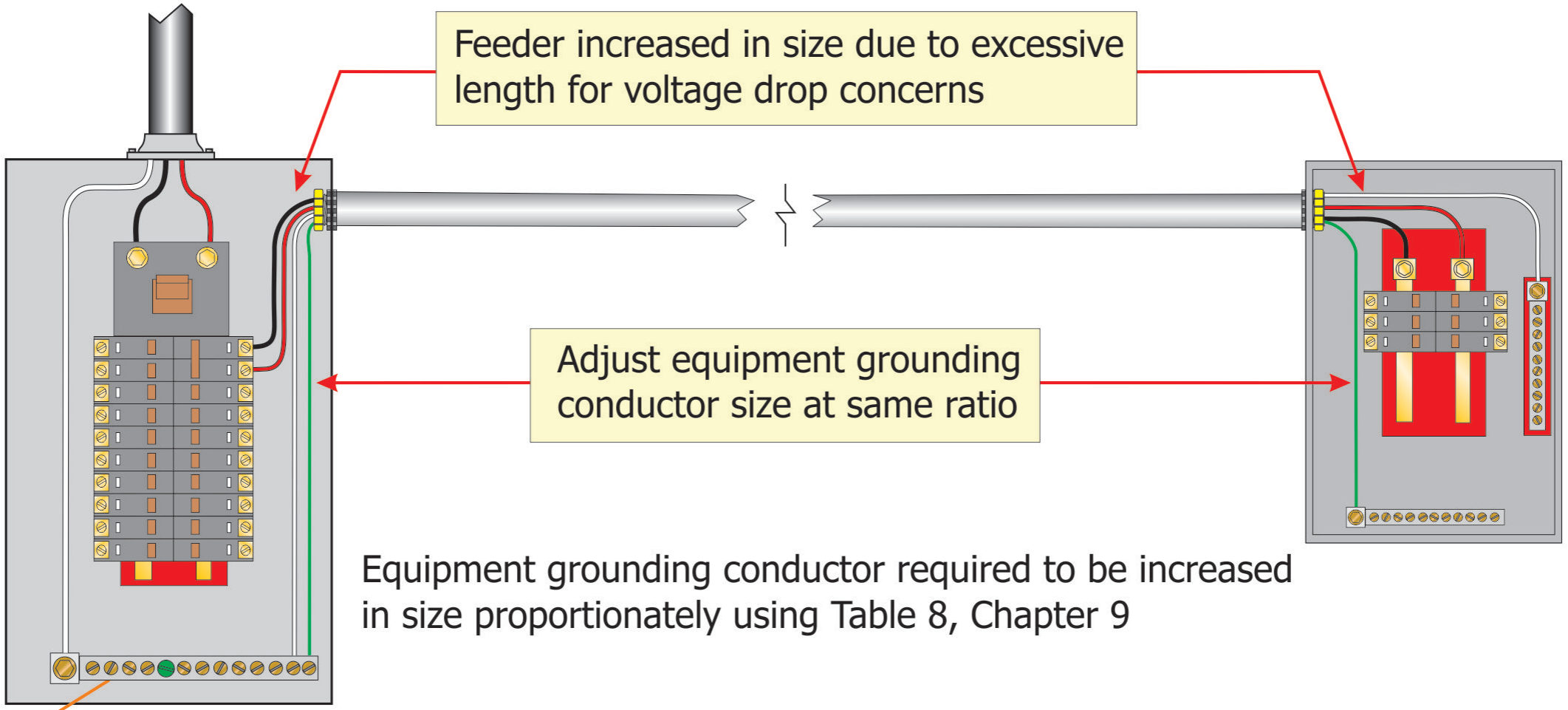
The structural metal frame of a building or structure shall not be used as an equipment grounding conductor



250.122(B) Adjustment of EGC Sizing

- Revisions clarify that **adjustment and/or correction factors** do not require an increase in the size of the equipment grounding conductor (EGC)
- If ungrounded conductors are increased in size for any reason **other than** as required in **310.15(B)** *(temperature adjustment factors)* or **310.15(C)** *(number of current-carrying conductors adjustment factors)*, wire-type EGCs, if installed, are required to be increased in size proportionately *(same ratio)* to the increase in circular mil area of the ungrounded conductors
- **New exception** added to allow the EGC to be sized by a **qualified person**, provided an effective ground fault current path can be established
- New exception will allow equipment grounding conductors to be sized by a "**qualified person**" to provide an effective ground fault current path rather than the **"ratio" method**

250.122(B) Adjusting Equipment Grounding Conductor Size



Equipment grounding conductor required to be increased in size proportionately using Table 8, Chapter 9

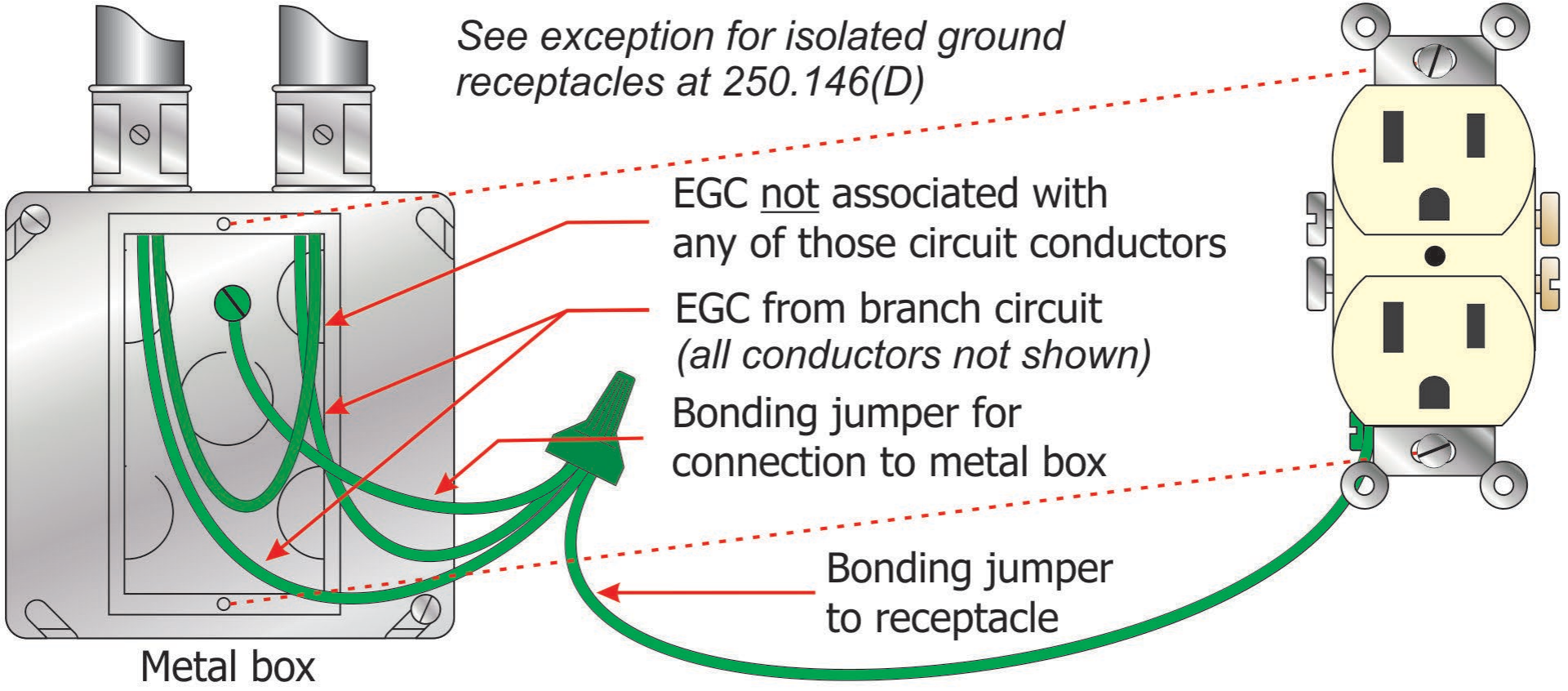
New exception permits equipment grounding conductors to be sized by a **qualified person** to provide an effective ground fault current path in accordance with 250.4(A)(5) or (B)(4)

250.148 Continuity of EGCs and Attachment in Boxes

- Revision clarifies that all wire-type equipment grounding conductors (EGC) associated with any spliced circuit conductors must be connected ***within*** the box or to the box
- Revision improve readability and clarify when EGCs within a box are intended to be connected together and bonded to a metal box or device
- Title was changed from “Continuity and Attachment of Equipment Grounding Conductors to Boxes” to “**Continuity of Equipment Grounding Conductors and Attachment in Boxes**”
- Emphasis was placed on the fact that only the EGCs associated with the spliced conductors are to be connected within the box or to the box
- Connecting all EGCs together, especially if of considerably different sizes, is impractical and unnecessary

250.148 Continuity of EGCs and Attachment *in* Boxes

If circuit conductors are spliced within a box or terminated on equipment within or supported by a box, all wire-type equipment grounding conductor(s) associated with any of those circuit conductors shall be connected within the box or to the box ~~with devices suitable for the use~~ in accordance with 250.8 and 250.148(A) through (D)



A connection used for no other purpose shall be made between the metal box and the equipment grounding conductor(s) in accordance with 250.8

250.184(C), Exception – Multigrounded Neutral Systems

- **New exception** added to relieve bonding the neutral conductor to a grounding electrode in an **uninterrupted conductor exceeding 400 m (1300 ft)** if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode in a multigrounded neutral system
- 250.184(C)(3) requires at least one grounding electrode to be installed and connected to the multigrounded neutral conductor every 400 m (1300 ft)
- National Electrical Safety Code (NESC) allows long cable runs such as those for wind farms and solar farms to still be considered multi-point grounded but not held to distances like the 400 m (1300 ft) maximum length between bonding of the neutral conductor to a grounding electrode

250.184(C), Exception – Multigrounded Neutral Systems

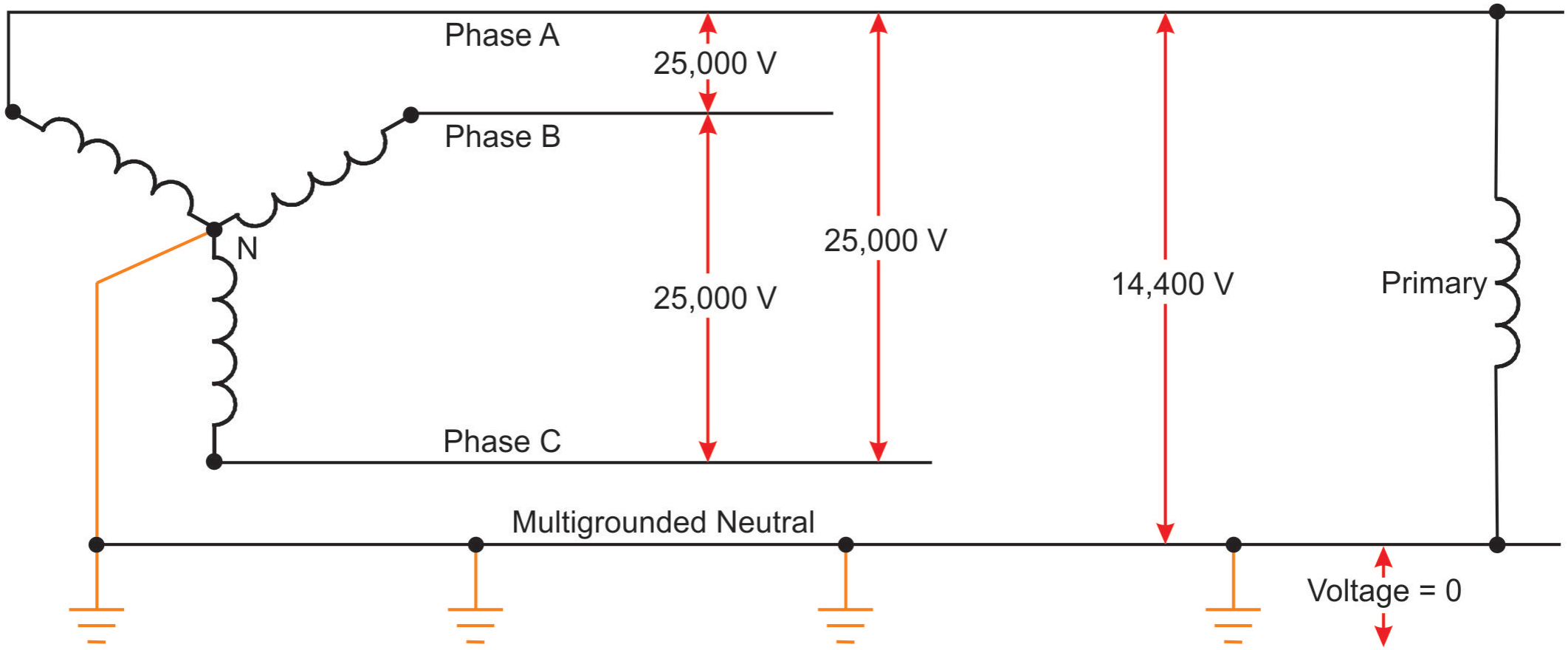
- **New exception** added to relieve bonding the neutral conductor to a grounding electrode in an **uninterrupted conductor exceeding 400 m (1300 ft)** if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode in a multigrounded neutral system
- 250.184(C)(3) requires at least one grounding electrode to be installed and connected to the multigrounded neutral conductor every 400 m (1300 ft)
- National Electrical Safety Code (NESC) allows long cable runs such as those for wind farms and solar farms to still be considered multi-point grounded but not held to distances like the 400 m (1300 ft) maximum length between bonding of the neutral conductor to a grounding electrode

250.184(C), Exception – Multigrounded Neutral Systems *(cont.)*

- **New exception** added to relieve bonding the neutral conductor to a grounding electrode in an **uninterrupted conductor exceeding 400 m (1300 ft)** if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode in a multigrounded neutral system *(cont.)*
- Removing the cable jacket only to create a point for connecting the multigrounded neutral conductor to a grounding electrode creates a **less desirable condition** than allowing further space between these connection points
- Removing the outer sheathing of the multigrounded neutral conductor cable creates a "**weak link**" in the cable that could lead to premature cable failure
- New exception in the *NEC* will align the NESC and *NEC* to avoid questions as to which standard has authority and brings consistency on this issue

250.184(C) Multigrounded Neutral Systems

Where a multigrounded neutral system is used, at least one grounding electrode shall be installed and connected to the multigrounded neutral conductor every 400 m (1300 ft)



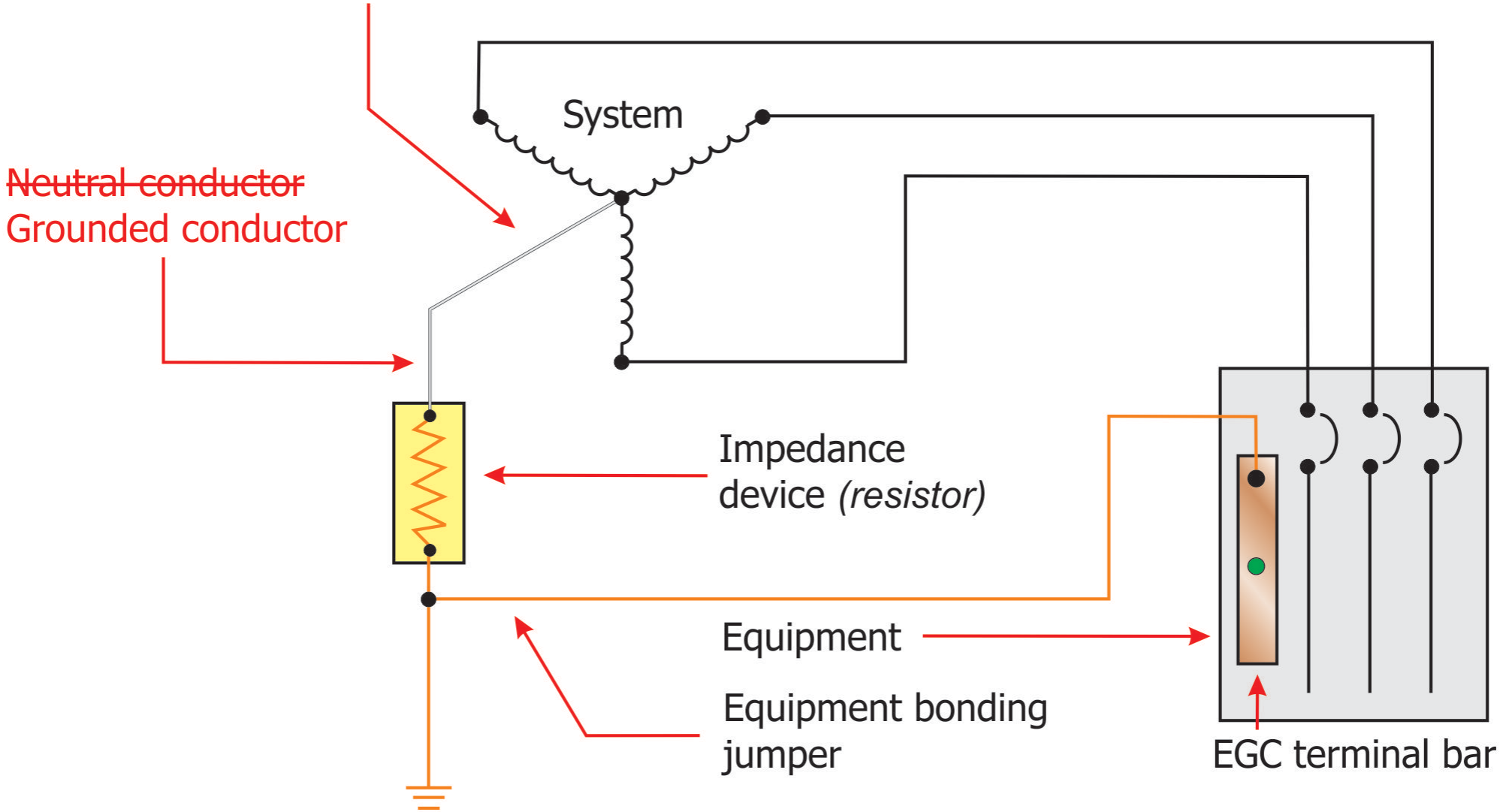
Exception: In a multipoint grounded system, a grounding electrode shall not be required to bond the neutral conductor in an uninterrupted conductor exceeding 400 m (1300 ft) if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode

250.187 Impedance Grounded ~~Neutral~~ Systems

- Revisions clarify that the conductor from the neutral point of a transformer to the grounding impedance device **does not meet the definition of neutral conductor** in Article 100 since it is not intended to carry current during normal operation
- The conductor from the neutral point of a transformer in this system to the grounding impedance device is now identified as a **grounded conductor**
- Title of **250.187(B)** was changed from “Identified and Insulated” to simply “**Insulated**” as a grounded conductor is already required to be identified or marked as a grounded conductor at **200.6**

250.187 Impedance Grounded ~~Neutral~~ Systems

The conductor from the neutral point of a transformer of an impedance grounded system to the grounding impedance device does not meet the definition of neutral conductor in Article 100 since it is not intended to carry current during normal operation



Chapter Three Wiring Methods and Materials

300.22(D) Wiring in Air-Handling Areas Under Raised Floors (ITE Rooms)

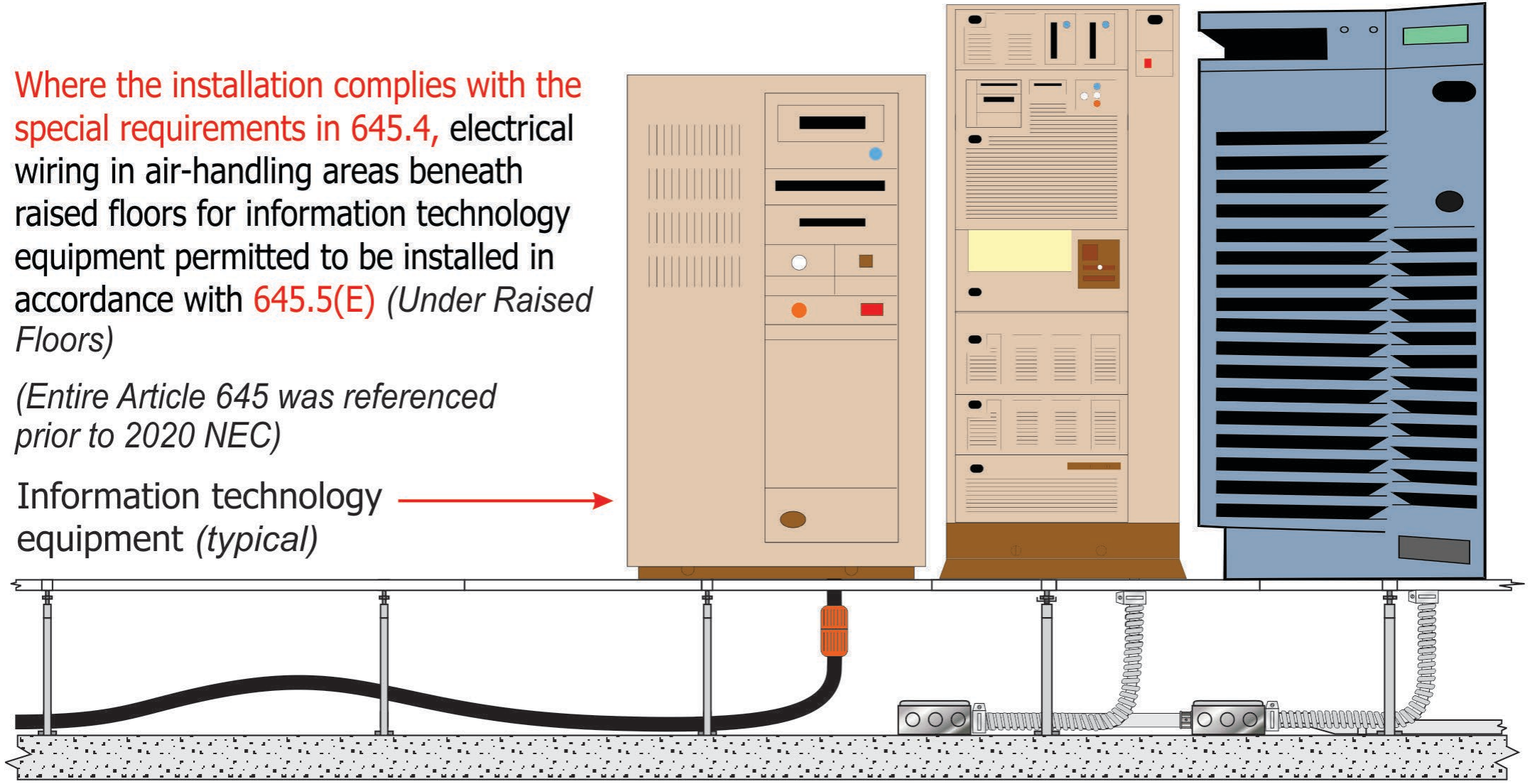
- Revision occurred to reference **645.5(E)** *(Supply Circuits and Interconnecting Cables – Under Raised Floors)* **rather than the entire Article 645** for electrical wiring in air-handling areas beneath raised floors for information technology equipment
- Installation must first meet the requirements of **645.4** *(Special Requirements for Information Technology Equipment Rooms)* so that 645.5(E) can permit the different requirements that normally would be required in 300.22(C) for wiring under raised floors

300.22(D) Wiring in Air-Handling Areas Under Raised Floors (ITE Rooms)

Where the installation complies with the special requirements in 645.4, electrical wiring in air-handling areas beneath raised floors for information technology equipment permitted to be installed in accordance with 645.5(E) *(Under Raised Floors)*

(Entire Article 645 was referenced prior to 2020 NEC)

Information technology equipment *(typical)*



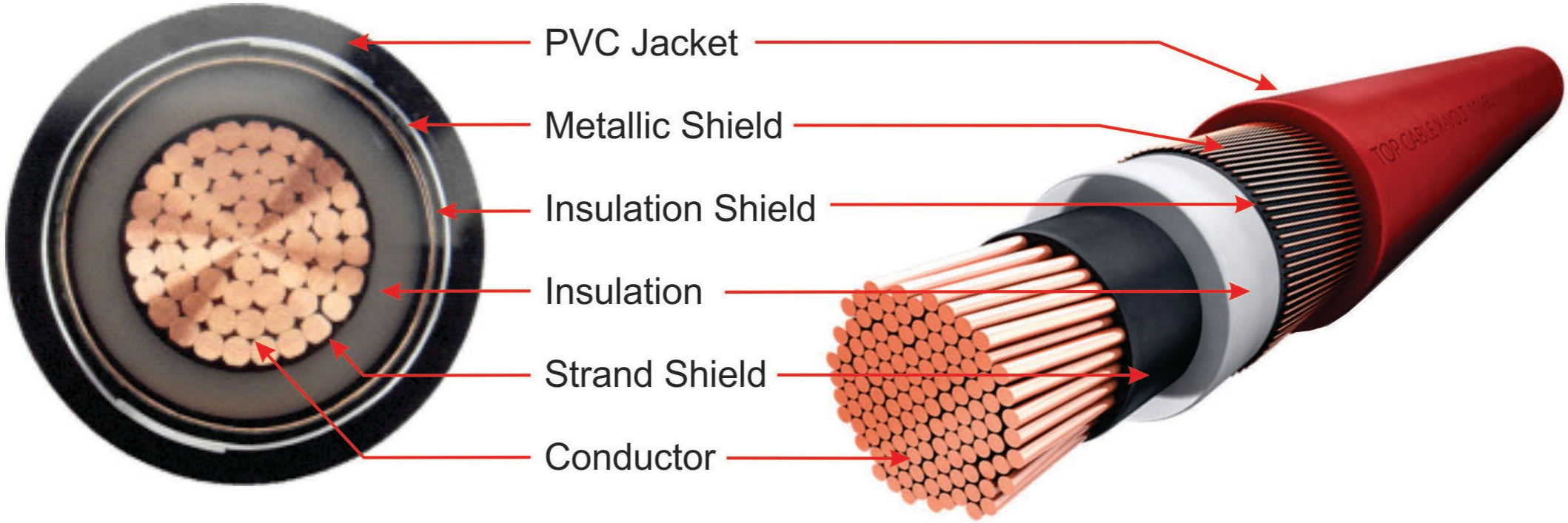
300.22(D) Wiring In Air-handling Areas Beneath Raised Floors For Information Technology Equipment

Article 311 Medium Voltage Cable (New)

- In order to consolidate the **medium voltage requirements** previously found in **Articles 310** *(Conductors or General Use)* and **Article 328** *(Medium Voltage Cable)*, and to improve the usability of the *Code*, the requirements are combined into a **new Article 311**
- New article will cover the use, installation, construction specifications and ampacities for medium voltage conductors and cable (Type MV)
- Part of the **Article 310** reorganization included moving the Type MV cable requirements into new **Article 311** which also included moving the Type MV cable requirements out of **Article 328** and deleting that article entirely
- Prior to this new article, it was difficult to gather all necessary information pertaining to Type MV conductors and cables as they were scattered within the Article 310 ampacity tables for cables up to 2000 volts

Article 311 Medium Voltage Cable

Medium voltage cable: A single or multiconductor solid dielectric insulated cable rated 2001 volts up to and including 35,000 volts, nominal.



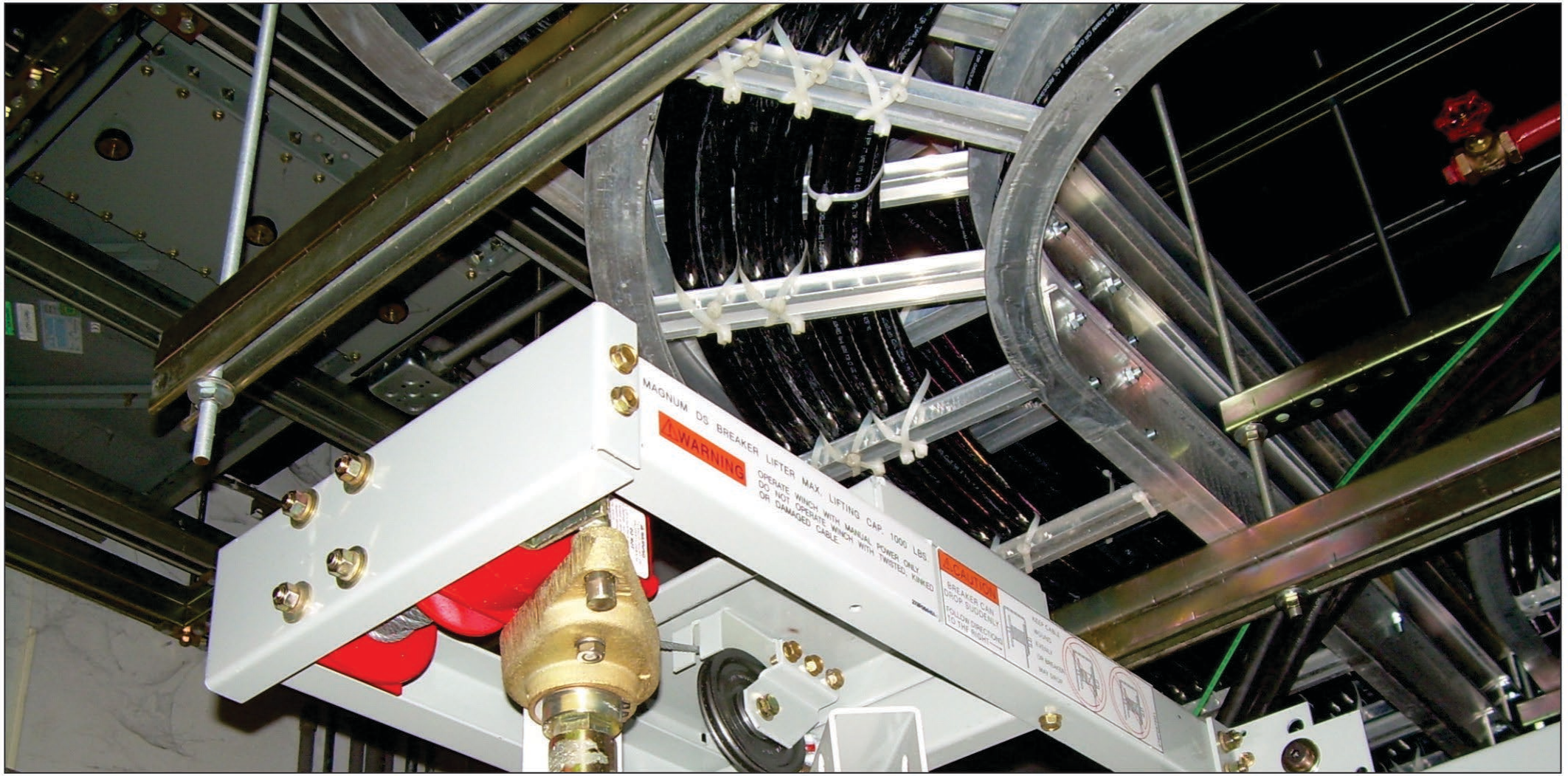
Medium voltage requirements previously found in Articles 310 and Article 328 have be combined into new Article 311 to improve the usability of the *Code*

392.30(B)(4) Cable Ties Used for Securement and Support in Cable Trays

- New provision added identifying **cable ties** used to secure and support conductors and cables in a cable tray as an **acceptable means of securement** when identified for securement and support in a cable tray
- Similar to existing requirements already in the *Code* for listing requirements for cable ties *[see 300.22(C)(1), 800.24]*
- If a cable tie is listed to **UL 1565** *(Positioning Devices)* under UL Product Spec category ZODZ, the cable tie has been identified for "**limited support**"
- If a cable tie is listed to **UL 62275** *(Cable management Systems-Cable Ties for Electrical Installations)*, cable tie retains 100% of its declared loop tensile strength (cable ties) or declared mechanical strength (fixing devices)

392.30(B)(4) Cable Ties For Securement and Support in Cable Trays

Cable ties used to secure conductors and cables in cable trays required to “be listed and identified for the application and for securement and support”

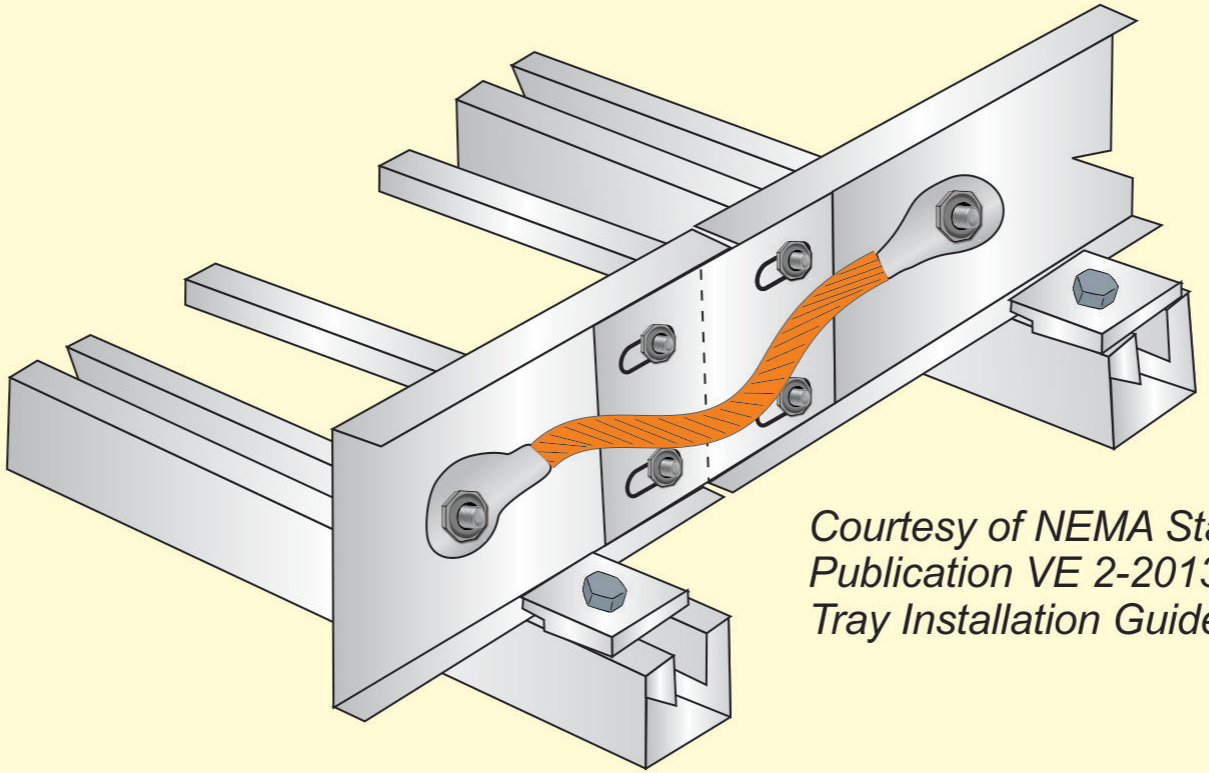


392.44 Expansion Splice Plates for Cable Trays

- New section added for **expansion splice plates** to address thermal expansion and contraction due to temperature variations for cable trays
- Important that cable tray installations incorporate features which provide adequate compensation for their **thermal contraction and expansion**
- The **length of a straight cable tray run** and the temperature differential will play a vital role in determining the number of expansion splice plates required
- Similar to existing requirements for **raceways** required to be provided with expansion, expansion-deflection, or deflection fittings where necessary to compensate for thermal expansion, deflection, and contraction *[see **300.7(B)**]*
- Expansion joint splice plates and bonding jumpers available from all major cable tray manufacturers

392.44 Expansion Splice Plates For Cable Trays

Expansion splice plates for cable trays required to be provided where necessary to compensate for thermal expansion and contraction



Courtesy of NEMA Standards Publication VE 2-2013 Cable Tray Installation Guidelines

Reproduction of Figure 3-38 Expansion Splice Plate Attachment

(NOTE: In Figure 3-38, a bonding jumper is not required for fiberglass cable tray systems.)

Chapter Four Equipment for General Use

410.69 Identification of Control Conductors

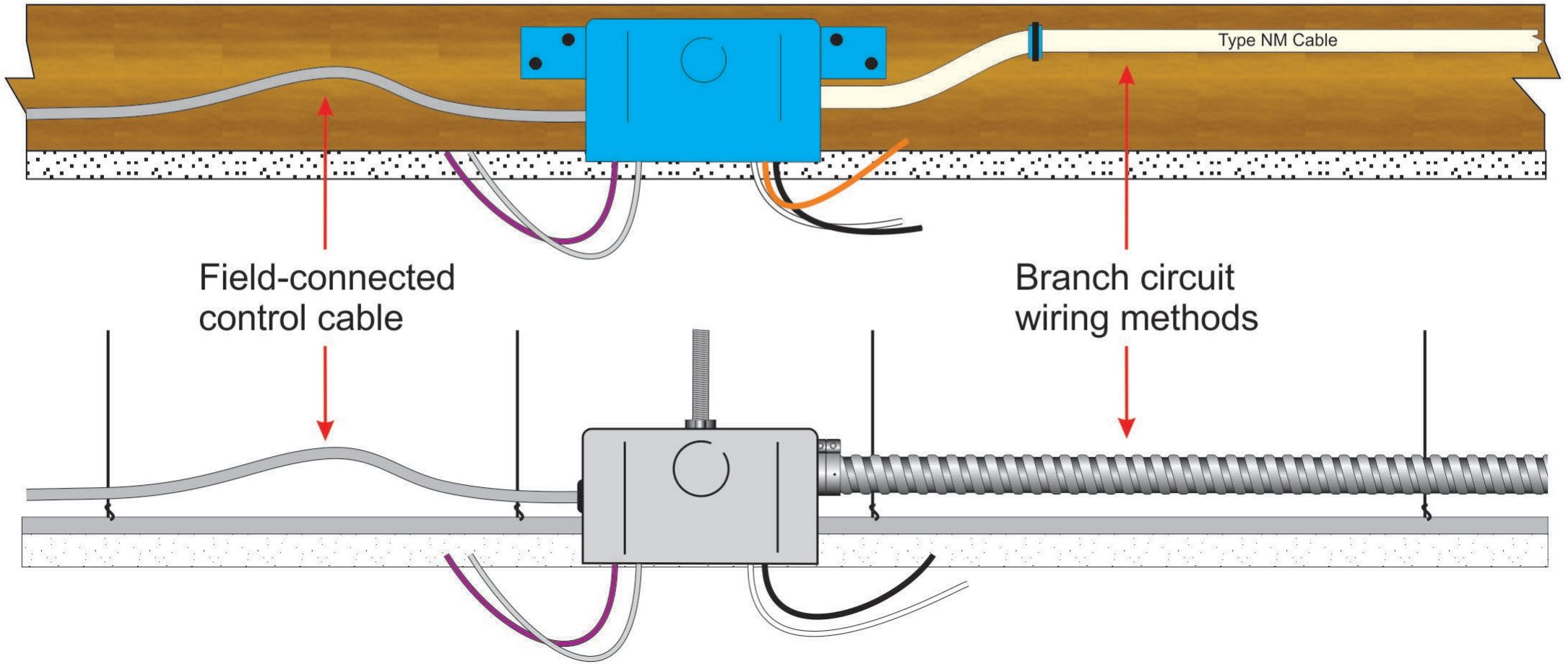
- New section added to prevent **lighting control conductors** from being installed using the **same color schemes** as the branch circuit grounded conductors and the equipment grounding conductor
- Future effective date of **January 1, 2022**
- Becoming more and more commonplace to control lighting with **low voltage** lighting control conductors and devices
- **Lighting control conductors** are used to communicate commands and other information between control devices in lighting system and the luminaire, etc.
- In today's modern social media society, for a more advanced functionality and flexible lighting system, **dedicated control wiring** may be needed

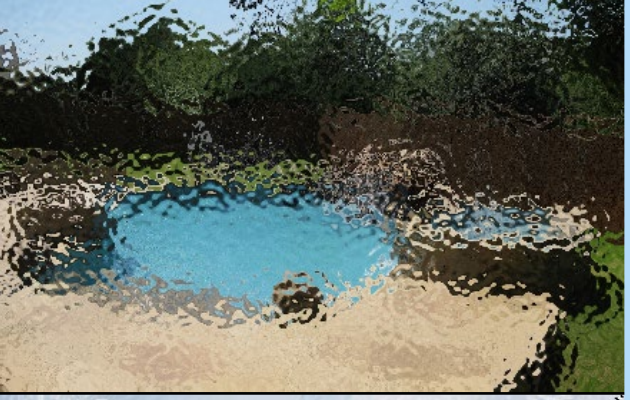
410.69 Identification of Control Conductors *(cont.)*

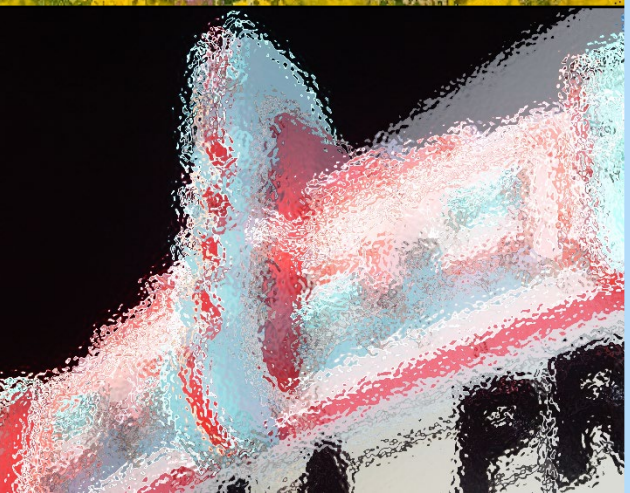
- New section added to prevent **lighting control conductors** from being installed using the **same color schemes** as the branch circuit grounded conductors and the equipment grounding conductor *(cont.)*
- This wiring is typically low voltage *(Class 2, 12–24-volt dc)*, providing a pathway for communication of analog or digital signals, such as incoming sensor input data *(lighting levels, occupancy sensing conditions, etc.)*
- Multiple **shock incidents** that have occurred and been reported involving the low voltage lighting control conductors being inadvertently spliced or connected to the grounded (neutral) conductor for the nominal voltage wiring system
- One very common lighting control conductor scheme is to use "**purple and gray**" colored lighting control conductors *("continuous white or gray outer finish" reserved for identification of grounded conductor systems)*

410.69 Identification of Control Conductor

Field-connected control conductor not permitted to utilize the same color identification scheme as reserved for the grounded branch-circuit conductor (white or gray) or the EGC (green) where control conductors are spliced, terminated, or connected in the same luminaire or enclosure as the branch-circuit conductors *(Future effective date of January 1, 2022)*







Chapter Six Special Equipment

600.2 Definitions – Electric Signs and Outline Lighting

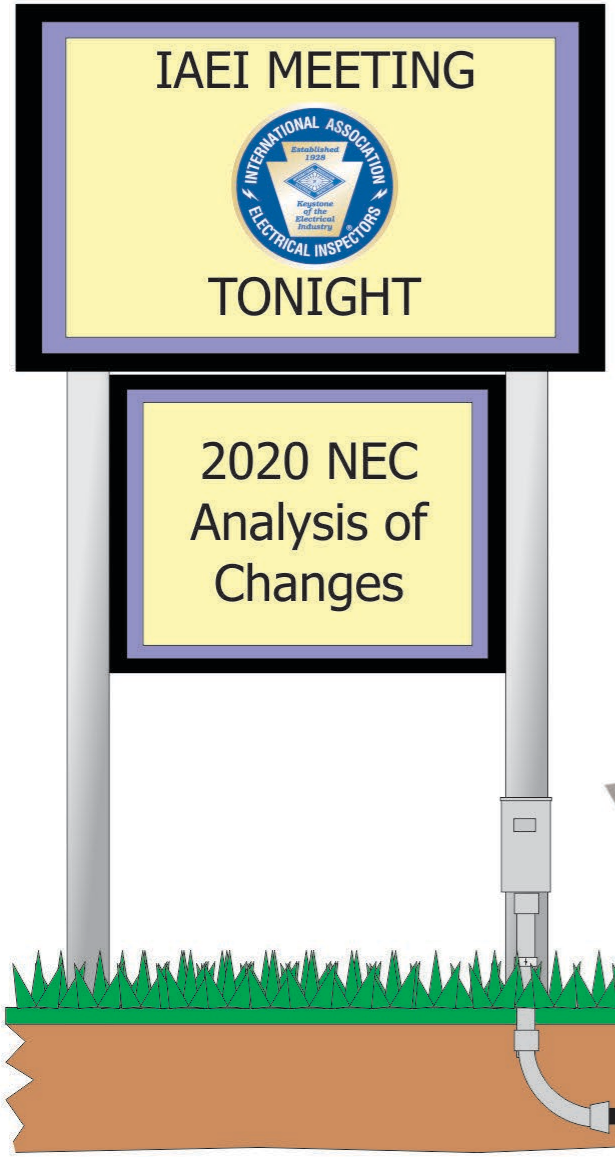
- **Four new definitions** were added to 600.2 pertaining to **retrofit kits for signs** (1) Host Sign, (2) Retrofit Kit, General Use, (3) Retrofit Kit, Sign Specific, (4) Subassembly
- Luminaires are typically standardized and are typically mass produced, whereas **signs** are typically **custom made** and have **distinctly different structural and illumination characteristics**, including multi-location corporate signage programs which are dissimilar in size
- A retrofit kit for a sign typically has **more "moving parts"** to deal with than a retrofit kit for a luminaire
- Concentrated efforts has been pursued in the sign industry to upgrade signs to achieve **greater energy efficiency** by replacing in-place illumination systems such as florescent with light emitting diodes (LED) technology

600.2 Definitions – Electric Signs and Outline Lighting *(cont.)*

- **Four new definitions** were added to 600.2 pertaining to **retrofit kits for signs** (1) Host Sign, (2) Retrofit Kit, General Use, (3) Retrofit Kit, Sign Specific, (4) Subassembly *(cont.)*
- An upgrade of the sign typically involves **field modifications** of the sign
- Proper adherence to **developed protocols** for these field conversions, such that when done within the testing laboratory parameters, ensures these field conversion “retrofit kits” do not compromise the safety profile of the listed sign
- These **added definitions** will aid the installer and the inspector in assuring the right retrofit kit is used with the correct host sign

600.2 Definitions. (Electric Signs and Outline Lighting)

Four new definitions were added to 600.2 pertaining to retrofit kits for signs



Host Sign. A sign or outline lighting system already installed in the field that is designated for field conversion of the illumination system with a retrofit kit.

Retrofit Kit, General Use. A kit consisting of primary parts, which does not include all the parts for a complete subassembly but includes a list of required parts and installation instructions to complete the subassembly in the field.

Retrofit Kit, Sign Specific. A kit consisting of the necessary parts and hardware to allow for field installation in a host sign, based on the included installation instructions.

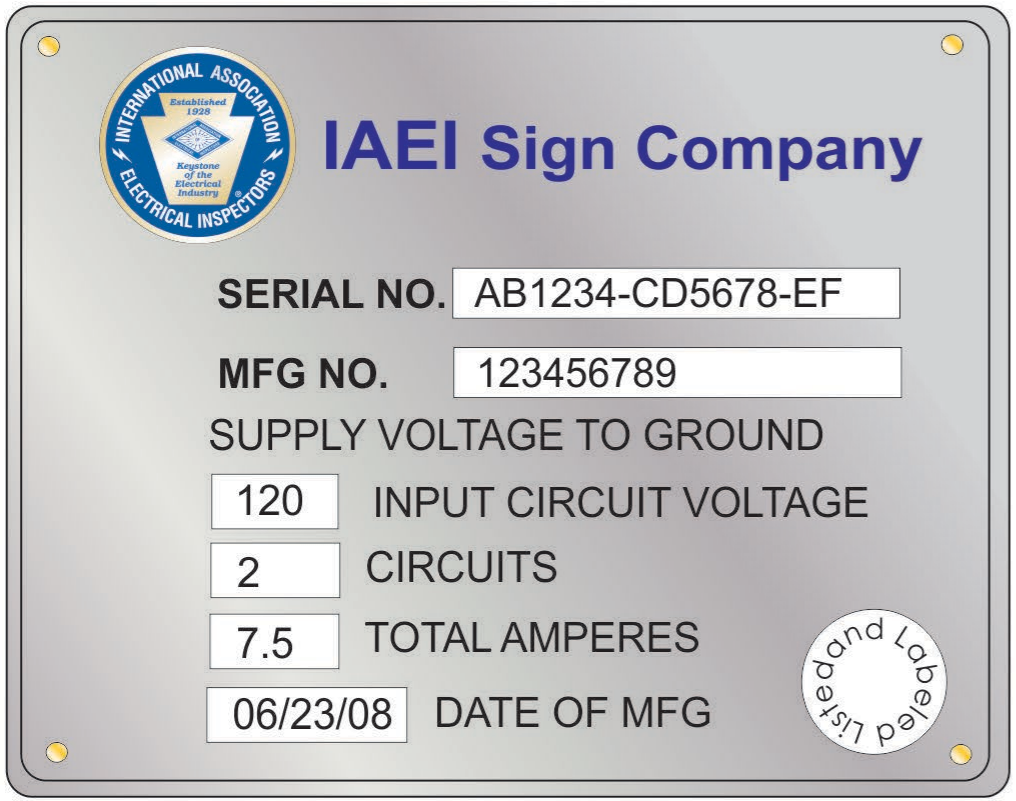
Subassembly. Component parts or a segment of a sign, retrofit kit, or outline lighting system that, when assembled, forms a complete unit or product.

600.4(D) Visibility of Markings for Electric Signs and Outline Lighting

- Revisions now require **visibility of markings** at the time of installation, inspection, and prior to servicing, but can be installed in a location **not viewed by the public**
- Previously, 600.4(A) markings and listing labels were not required to be visible after installation, but were required to be permanently applied in a location **visible during servicing** *(rather than **prior to servicing**)*
- This marking would include such things as manufacturer's name, trademark, maximum allowable lamp wattage, input voltage, and current rating
- New *Code* text was added to clarify that "***visible after installation***" does not necessarily mean visible in a location viewed by the public
- When an installer or inspector first approaches a sign, they should be able to identify **input voltage** and **current rating** prior to opening the sign

600.4(D) Visibility of Markings - Electric Signs and Outline Lighting

Signs and outline lighting systems required to be marked with such things as manufacturer's name, trademark, input voltage and current rating, maximum allowable lamp wattage per lampholder, and other means of identification [600.4(A) and (C)]



Markings and listing labels are required to be visible after installation and must be permanently applied in a location visible prior to servicing

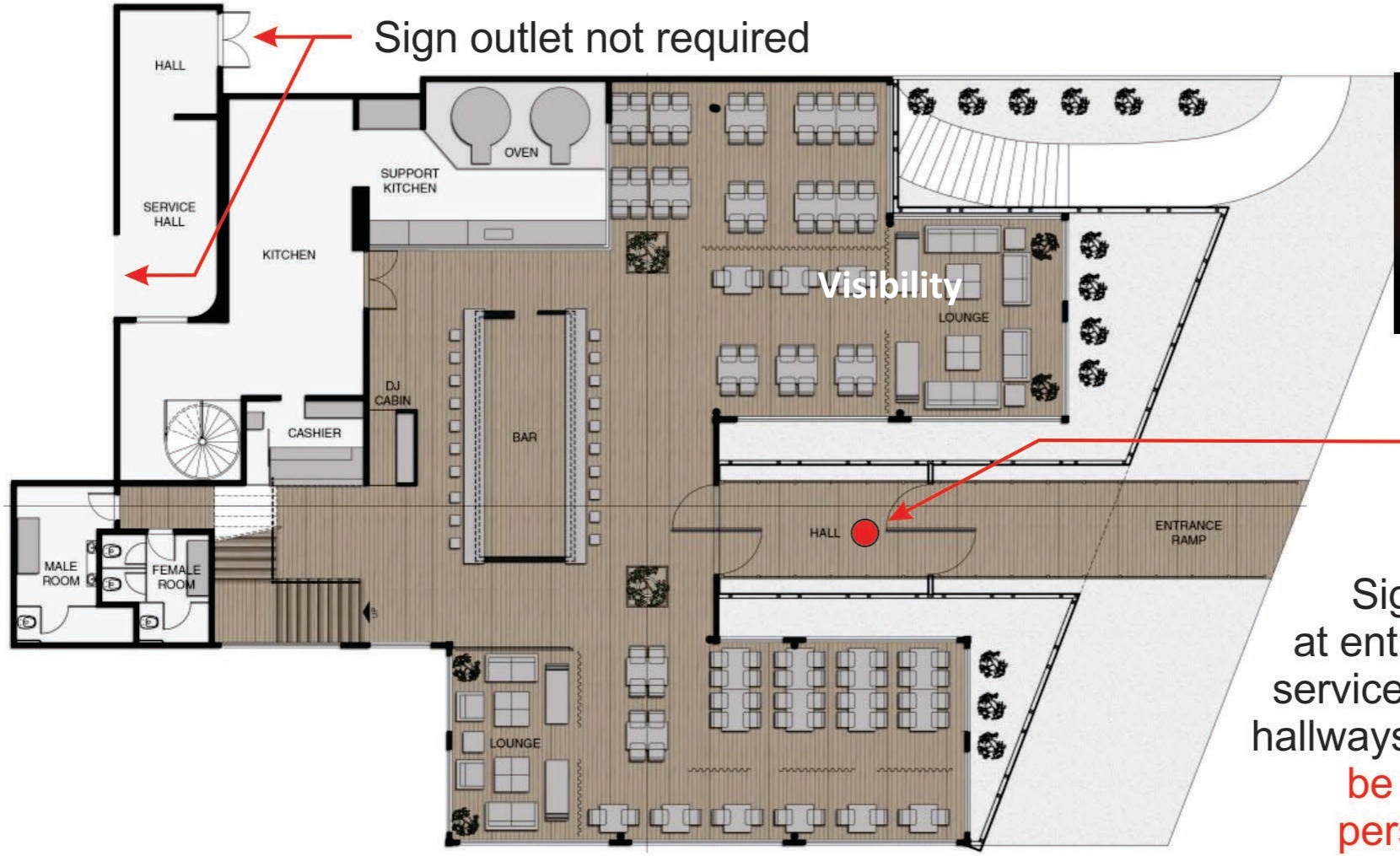
Marking permitted to be installed in a location not viewed by the public

600.5(A) Required Branch Circuit for Electric Signs and Outline Lighting

- Revision clarifies that **entrances not accessible to customers**, such as delivery doors, **do not require a sign outlet**
- At each commercial building and each commercial occupancy accessible to pedestrians, at least one outlet *(located in an accessible location)* is required to be installed at each entrance to each tenant space for a sign or outline lighting system
- A sign or outline lighting outlet **not required** at entrances for deliveries, service corridors, or service hallways that are intended to be used only by service personnel or employees
- Clarification was needed to distinguish what entry doors did and did not require this required sign outlet

600.5(A) Required Branch Circuit for Electric Signs/Outline Lighting

At each commercial building and each commercial occupancy accessible to pedestrians, at least one outlet is required to be provided at an accessible location for each entrance to each tenant space for a sign or outline lighting system *(required to be supplied by a 20-ampere branch circuit with no other loads)*



Sign outlet not required at entrances for deliveries, service corridors, or service hallways that are intended to be used only by service personnel or employees

690.2 Definitions: ~~Functional~~ Grounded, Functionally ~~PV System~~

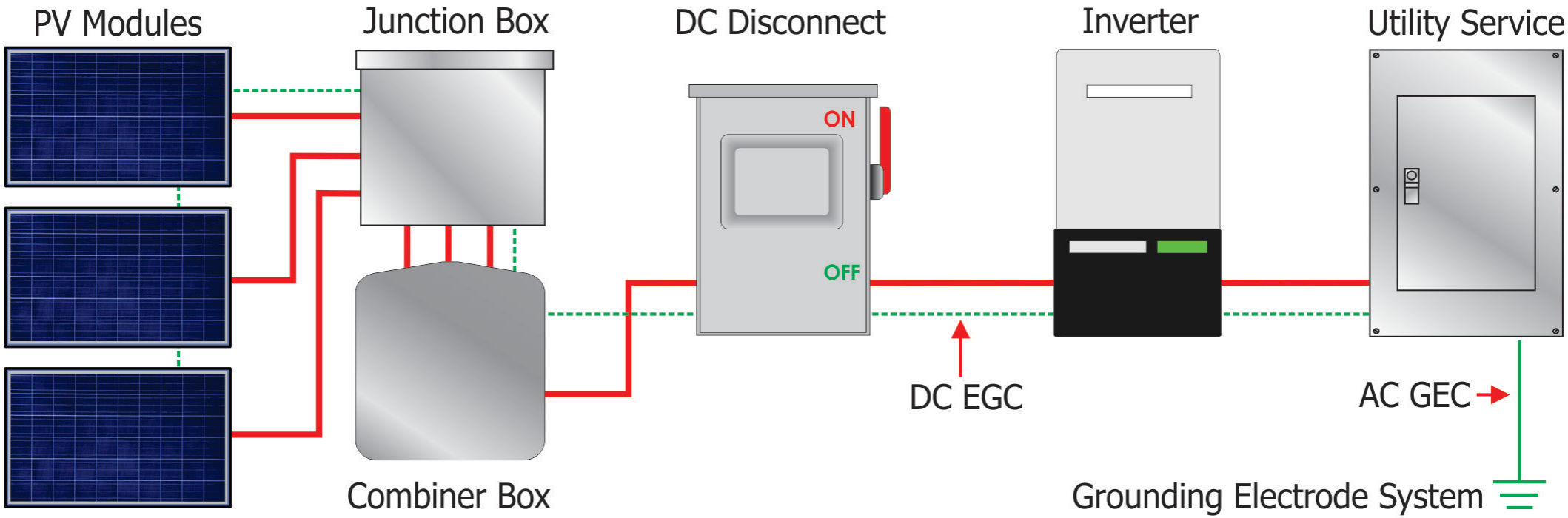
- The previous definition for "**Functional Grounded PV System**" was revised to "**Grounded, Functionally**"
- **Informational Note** also revised to clarify the operational purposes for a functionally grounded system and to indicate that ground faults are only one reason to employ a functionally grounded system
- Changed to "**Grounded, Functionally**" to follow the format in Article 100 as this definition is used in multiple articles such as Article 705, 706, and 712
- Text in the previous definition was **vague and misleading** since functionally grounded PV systems *(without a point of direct connection to a grounding electrode system)* is only permitted through the use of a **listed ground-fault protection system** that will open all of the ungrounded conductors of a system when a fault is detected in accordance with **690.41(A) or (B)**
- To accomplish this detection, an **equipment grounding connection** is necessary as a reference to a grounding system since the functionally grounded system is effectively isolated from a ground reference until a ground fault is sensed

690.2 Definitions: ~~Functional~~ Grounded, Functionally ~~PV System~~ *(cont.)*

- The previous definition for "**Functional Grounded PV System**" was revised to "**Grounded, Functionally**" *(cont.)*
- Most PV systems installed in the past decade or so are actually functionally grounded systems rather than solidly grounded systems as defined in Article 100
- For functionally grounded PV systems with an interactive inverter output, the ac equipment grounding conductor is connected to associated grounded ac distribution equipment
- This connection is often the connection to ground for ground-fault protection and equipment grounding of the PV array

690.2 Definition: Grounded, Functionally

~~**Functional**~~ **Grounded, Functionally** ~~**PV System**~~**.** A system that has an electrical ground reference for operational purposes that is not solidly grounded.



Informational Note: A functionally grounded system is often connected to ground through an electronic means internal to an inverter or charge controller that provides ground-fault protection. Examples of operational purposes for functionally grounded systems include ground-fault detection and performance-related issues for some power sources.

690.4(B) PV Equipment Listing and Evaluation

- Revision clarifies that if the **listed PV equipment** is not **listed for the application** then it must be **field evaluated** by a NRTL or Field Evaluation Body (FEB) and have a field label applied if it passes the evaluation
- Inverters, motor generators, PV modules, ac modules and ac module systems, dc combiners, dc-to-dc converters, rapid shutdown equipment, dc circuit controllers, and charge controllers **intended for use in PV systems** are now required to be listed or be **evaluated for the application** and have a **field label applied** *(function of the "field evaluation" process)*
- New *Code* language added to not just require this equipment to be "**field labeled**" but be "**evaluated**" for the intended application
- Equipment that is listed for the application means that it is intended for use in that application

690.4(B) PV Equipment Listing and Evaluation

Equipment intended for use in PV systems required to be listed or be evaluated for the application and have a field label applied

- Equipment required to be listed or evaluated:
- Inverters
- Motor generators
- PV modules
- ac modules and ac module systems
- dc combiners
- dc-to-dc converters
- Rapid shutdown equipment
- dc circuit controllers
- Charge controllers

690.8(A) PV Circuit Sizing and Calculation of Maximum Circuit Current

- 690.8(A) was reorganized to provide improvement to the understanding of the requirements for PV circuit sizing and current
- Maximum current for specific PV circuits are now calculated in accordance with **690.8(A)(1) through (A)(2)**, with previous 690.8(A)(2), (A)(3), (A)(5), and (A)(6) incorporated into **revised 690.8(A)(1)**
- Language was added to clarify that calculations for these circuits have **options**, however, the **secondary options** in 690.8(A)(1)(b) and 690.8(A)(1)(a)(2) contain **restrictions**
- New **690.8(A)(2)** titled, "**Circuits Connected to the Input of Electronic Power Converters**" added to provide provision pertaining to the case in stand-alone inverter input circuit currents *[previous 680.8(A)(4)]*
  - This section includes clarifying language to require an overcurrent device in accordance with **240.4(B)** to address the allowance to **round up to the next standard size**


RHW-2 2000V
Ø8-HCB-19B-Ø1-Ø1(+)
Ø8-HCB-19B-Ø1-Ø1(+)
PV WIRE 8 AI
Ø8-HCB-19B-Ø1-Ø2(+)
Ø8-HCB-19B-Ø1-Ø2(+)
CU 2000V 90°C WET OR DR
RHW-2 2000V
Ø8-HCB-19B-Ø1-Ø3(+)
Ø8-HCB-19B-Ø1-Ø3(+)

690.9(A) Overcurrent Protection for PV Circuits and Equipment

- Revision reorganizes **690.9(A)** for **overcurrent protection** to eliminate previous exception with three List Items created for unique and different protection scenarios

- The previous exception was written in positive *Code* language and transformed into **new 690.9(A)(1)** *(Circuits Where Overcurrent Protection Not Required)* with two conditions that must be meet in order to not have to provide overcurrent protection

- New **690.9(A)(2)** addresses circuits connected to current limited sources

- New **690.9(A)(3)** titled "**Other Circuits**" captures all remaining options covered under this section with four protection options

690.9(A) Overcurrent Protection for PV Systems

690.12 Rapid Shutdown of PV Systems on Buildings

- The requirements for a **Rapid Shutdown** of PV systems received extensive revision again this *Code* cycle
- The **2014 *NEC*** genesis of the rapid shutdown requirements of 690.12 were launched with the United States Department of Homeland Security (DHS) Assistance to Firefighter grant program
- For the **2017 *NEC***, the rapid shutdown requirements of 690.12 was revised to emphases the primary existence of the rapid shutdown requirements is to **reduced shock hazard for emergency responders** and to answer questions regarding the functionality of the PV rapid shutdown device itself
- This pattern of revision continued for the **2020 *NEC***

690.12 Rapid Shutdown of PV Systems on Buildings *(cont.)*

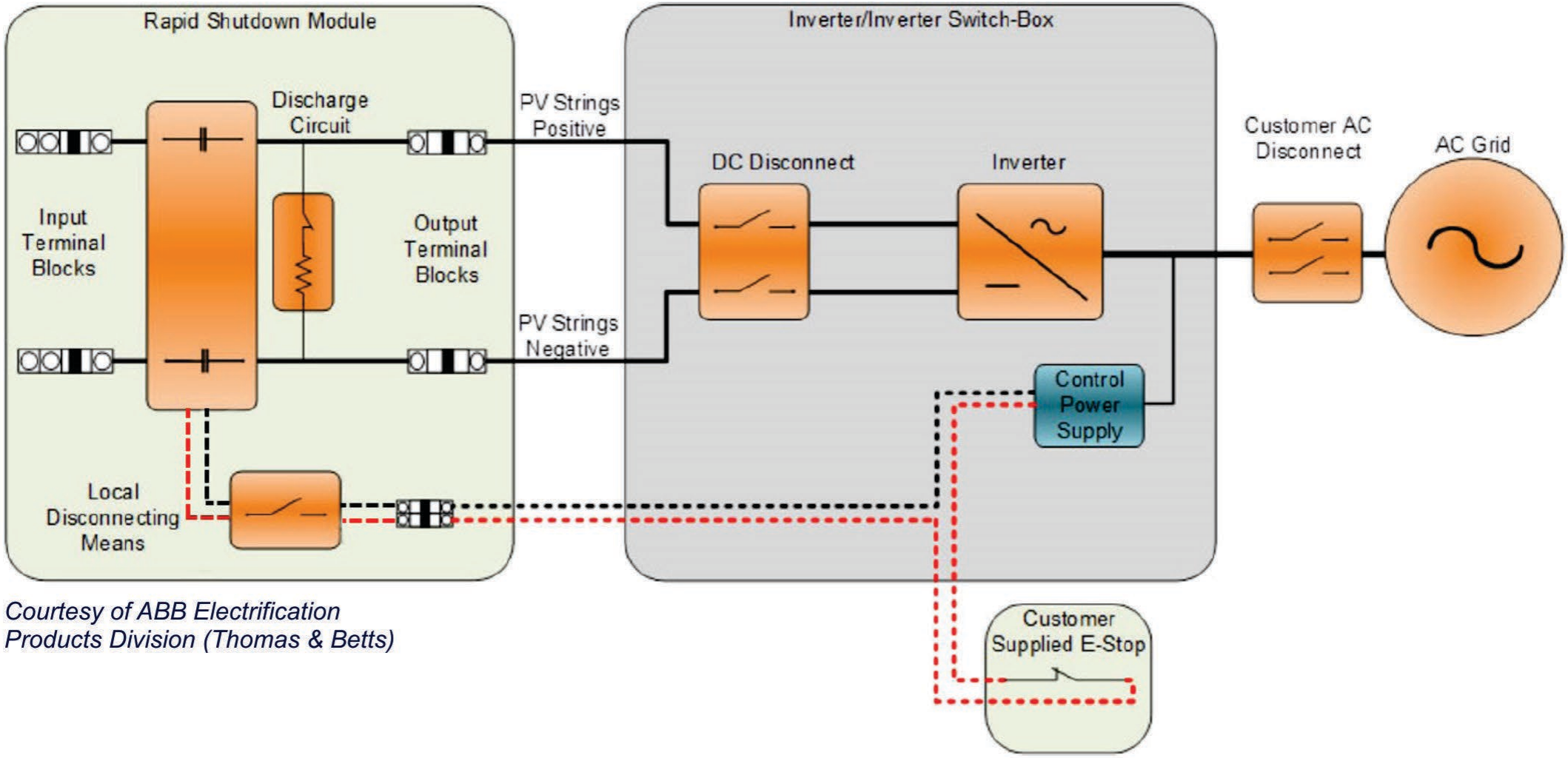
- The requirements for a **Rapid Shutdown** of PV systems received extensive revision again this *Code* cycle *(cont.)*
- A **new product standard** has been developed by UL so that hazardous energy levels within a PV array can be reduced when firefighters or other emergency response personnel are required to enter the array area to mitigate emergency conditions
- See **UL 3741** *(Standard for Safety Photovoltaic Hazard Control)*
- Parent text of 690.12 "**emergency responders**" replaced with "**fire fighter**" to narrow down exactly who the rapid shutdown function is intended for which harmonizes this *Code* text with **UL 3741**

690.12 Rapid Shutdown of PV Systems on Buildings *(cont.)*

- The requirements for a **Rapid Shutdown** of PV systems received extensive revision again this *Code* cycle *(cont.)*
- Revision to **690.12(A)** *(Controlled Conductors)* define what conductors are to be controlled; **(1)** PV system dc circuits and **(2)** Inverter output circuits
- **690.12(B)** *(Controlled Limits)* revised to indicate that controlled conductors **outside** the array boundary comply with **690.12(B)(1)** and **inside** the array boundary comply with **690.12(B)(2)**
- New *Code* text added at **690.12(C)** to address cases where more than one initiation device is used on a single PV system
- Previous **informational note** following **690.12(D)**, *(inverter input circuit conductors often remain energized for up to 5 minutes with inverters not listed for rapid shutdown)* **deleted** as informational note no longer needed

690.12 Rapid Shutdown of PV Systems on Buildings

Rapid shutdown requirements revised extensive revision to emphases the primary existence of rapid shutdown requirements is to reduced shock hazard for fire fighters



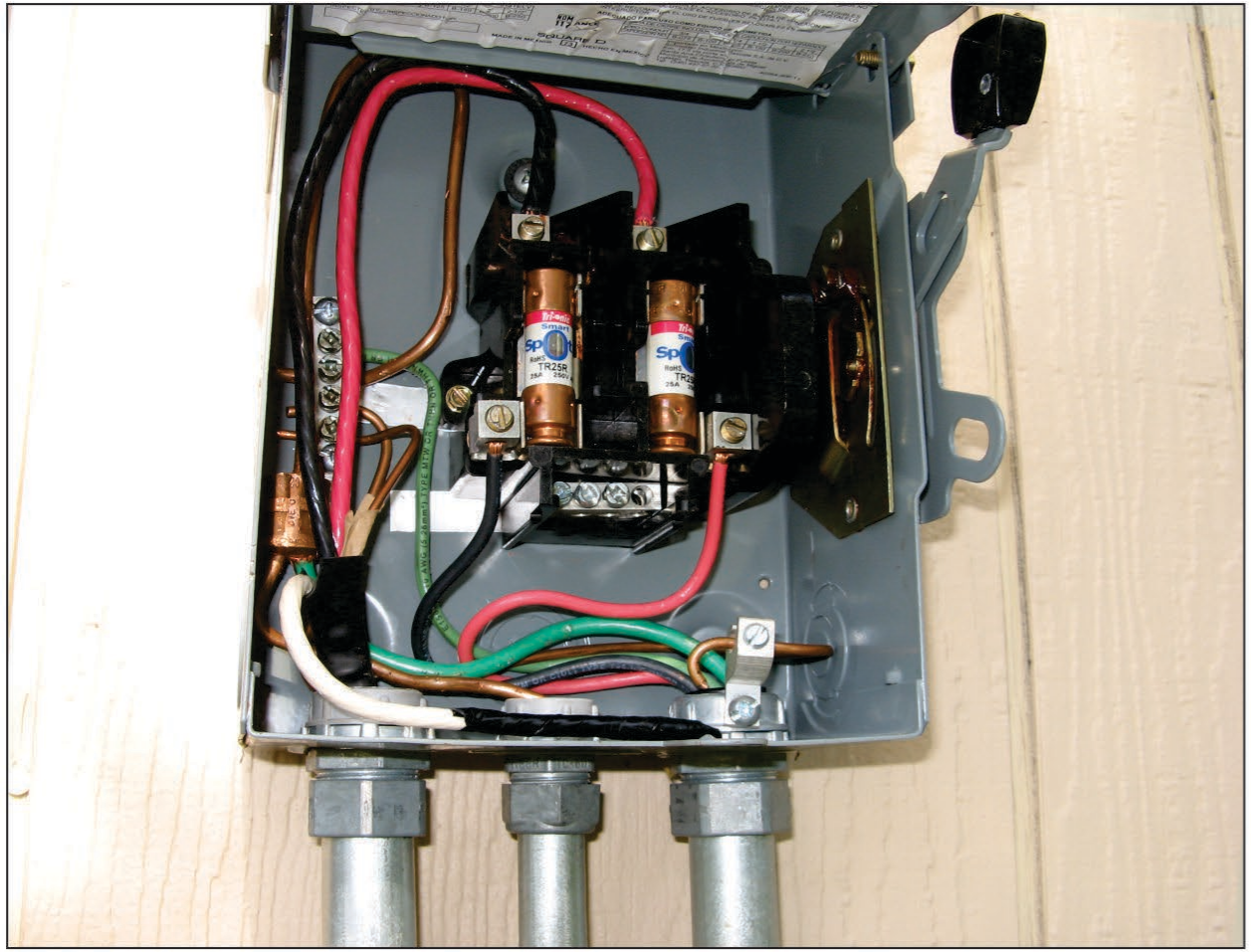
Courtesy of ABB Electrification Products Division (Thomas & Betts)

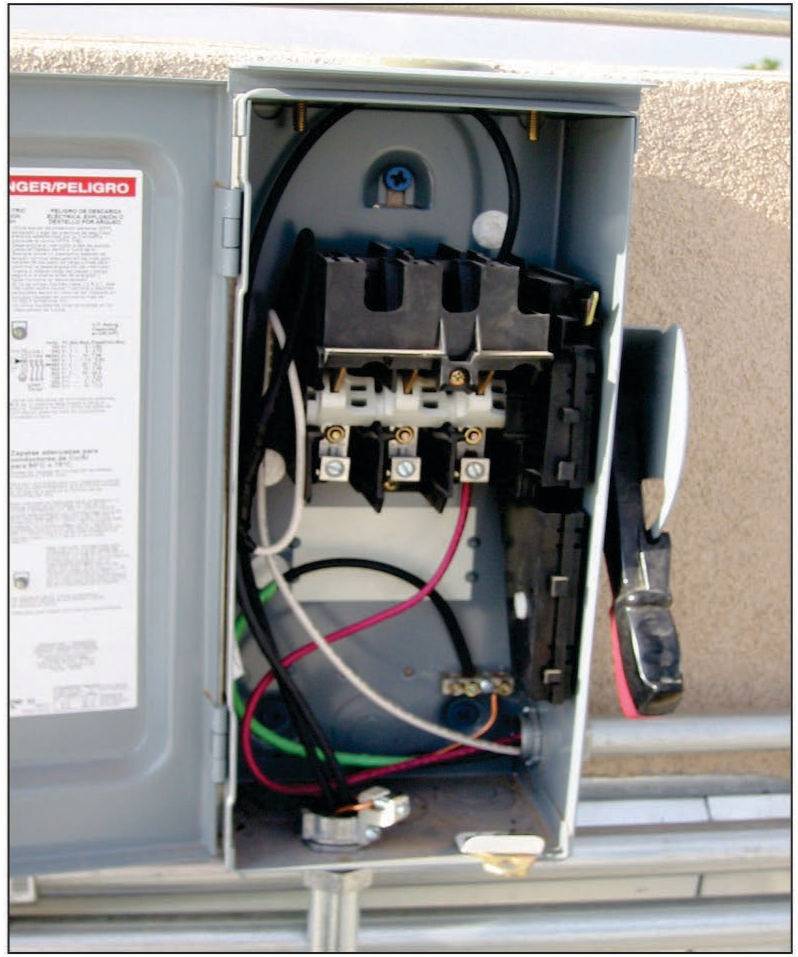
690.13(A) PV System Disconnecting Means

- New requirement calling for the PV disconnecting means to be **lockable or require a tool to open** under certain conditions
- New requirement calls for any PV disconnect enclosure with a door or hinged cover that exposes live parts when open to be **locked or require a tool to open** where a disconnecting means of systems **above 30 volts are readily accessible to unqualified persons**
- Similar format to **110.31(D)** *(Enclosed Equipment Accessible to Unqualified Persons)* which addresses equipment accessible to unqualified persons
- Installation of PV systems has created numerous opportunities for PV disconnect switches to be located in positions that are **accessible by other than qualified personnel** *(children in some instances)*
- Same basic change occurred at **690.15(A)** for the isolating devices or disconnecting means for PV equipment and **705.20(5)** for the disconnecting means for interconnected electric power production sources

690.13(A) Photovoltaic System Disconnecting Means

PV system disconnecting means are required to be installed at a readily accessible location





Where PV disconnecting means (above 30 volts) are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open is now required to be locked or require a tool to open

690.13(E) Type of PV System Disconnecting Means

- Previous (3) List Items under "**Type of Disconnect**" removed and the revision summarizes the type of disconnects that may be used as a PV system disconnect with **lockability requirements** of **110.25** included
- Previous provisions at 690.13(F)(1), (F)(2) and (F)(3) pertaining to "**backfeed**" operations has been **removed** and referenced in a **new Informational Note** following 690.13(E)
- Revision clarifies that all **non-solidly grounded conductors** must be disconnected, but the **ac grounded (neutral) conductors** *(which are solidly grounded)*, are not required to be disconnected
- Type PV system disconnecting means allowed was put into a **list format** *[similar to the list that was found at previous 690.15(D)]*


PV SYSTEM
PHOTOVOLTAIC DISCONNECTING MEANS
ON
SIEMENS
General Duty Safety Switch
200A 240VAC, 250VDC
Horsepower Rated
DANGER
Hazardous Voltage. Will cause death or serious injury.
OFF
NORMAL AC OUTPUT CURRENT: 120A
NORMAL OPERATING AC VOLTAGE: 208V
PHOTOVOLTAIC SYSTEM AC DISCONNECT
- WARNING - ELECTRIC SHOCK HAZARD
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.
PARALLEL ON-SITE SOLAR GENERATION. PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN.
DANGER
PELIGRO
PARALLEL ON-SITE SOLAR GENERATION. PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN.
MILBANK

690.15 Disconnecting Means for Photovoltaic Equipment

- Requirements for **disconnecting means** for **isolating PV equipment** of PV systems received **extensive revision** to emphasis isolation of equipment from energized conductors
- The original 1984 *NEC* title was changed from "**Disconnection of Photovoltaic Equipment**" to "**Disconnecting Means for Photovoltaic Equipment**"
  - Previous title was misleading and could be interpreted to refer to disconnecting means that is discussed at **680.13**
  - Section is intended to address isolation of equipment from energized conductors (isolated)
  - Does not necessarily have to be accomplished by an equipment disconnecting means

690.15 Disconnecting Means for Photovoltaic Equipment *(cont.)*

- Requirements for **disconnecting means** for **isolating PV equipment** of PV systems received **extensive revision** to emphasis isolation of equipment from energized conductors *(cont.)*
- Revision occurred at the parent text of **690.15** to point directly to 690.15(D) to clarify the types of disconnecting means allowed for isolation of PV equipment
- A provision was added at the end of **690.15(A)** requiring the disconnecting means of equipment operating above 30 volts and readily accessible to unqualified persons to be lockable and locked or require a tool to open
- **Previous 690.15(B)** titled, “Interrupting Rating” was **deleted** as this information is covered and better suited for the disconnecting means requirements of **690.13(D)** *[previously 690.13(E)]*

690.15 Disconnecting Means for Photovoltaic Equipment *(cont.)*

- Requirements for **disconnecting means** for **isolating PV equipment** of PV systems received **extensive revision** to emphasis isolation of equipment from energized conductors *(cont.)*
- **New 690.15(B)** *[previously 690.15(C)]* titled, "**Isolating Device**" had new language added to point out the fact that an isolating device is **not required** to have an **interrupting rating** *(can have an interrupting rating, but not required)*
- A new first sentence was added to **690.15(C)** to address the language removed from previous 690.15(B) on **interrupting ratings** and added fault current
- The lockability requirement of **690.15(C)** changed so that this would only be applicable to cases where the disconnecting means is **more than 3 m (10 ft)** from the equipment or not within site of the equipment

690.15 Disconnecting Means for Photovoltaic Equipment *(cont.)*

- Requirements for **disconnecting means** for **isolating PV equipment** of PV systems received **extensive revision** to emphasis isolation of equipment from energized conductors *(cont.)*
- A new **690.15(D)** added titled, "**Type of Disconnecting Means**," which is intended to clarify the requirements related to disconnection of equipment
- Two different requirements for these devices:
  - Circuits with a **maximum circuit current over 30 amperes** must have devices that comply with **new 690.15(D)** as these conversion devices can present a load to the fault current limited circuit
  - Circuits **under 30 amperes** where isolation is required for servicing equipment, *Code* language was added to make it clear that isolating devices are permitted

690.15 Disconnecting Means for Photovoltaic Equipment

Requirements for disconnecting means for isolating PV equipment of PV systems received extensive revision to emphasis isolation of equipment from energized conductors

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems

- Revisions to **690.31** organized **PV wiring methods** into one section
- Wiring methods for PV installations were previously located in various areas
- New sentence added to **690.31(A)** to introducing a revised table [**Table 690.31(A)(a)**] and a **new Table 690.31(A)(b)**
  - Revision cleans up **Table 690.31(A)(a)** [formerly Table 690.31(A)] by only including correction factors for 105°C (221°F) and 125°C (257°F) as all other correction factors are in Article 310
  - The temperature ranges above 30°C are given in 5°C increments
  - New ampacity table for 105°C (221°F) and 125°C (257°F) has been added as **new Table 690.31(A)(b)**

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems *(cont.)*

- Revisions to **690.31** organized **PV wiring methods** into one section *(cont.)*
- Additional clarity was needed at **690.31(B)** to address the most common application of this requirement for enforcers; installation of inverter dc input conductors and ac output conductors in the **same wireway** below an inverter
- **690.31(B)(2)** permitted the installation of those same conductors *(even if from different PV systems)* within the same raceway or junction box with a removable cover without a barrier or partition
- **Exception** to **690.31(B)(2)** even deleted the grouping requirement where the conductors enter the enclosure through separate means
- **690.31(B)** revised to provide needed **lines of demarcation** for conductors of dc and ac PV systems

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems *(cont.)*

- Revisions to **690.31** organized **PV wiring methods** into one section *(cont.)*
- Several of the items in 690.31 are directly related to cables and those **cable requirements** were consolidated in the new and revised **690.31(C)**
- *Code* language added to the parent text of **690.31(C)** pertaining to the listing requirement for **Photovoltaic (Type PV) wire or cable** and **Distributed Generation (Type DG) cable** with a new informational note added to direct users of the *Code* to **UL 4703** *(Standard for Photovoltaic Wire)* and **UL 3003** *(Distributed Generation Cables)*
- Requirements of **690.31(C)(1)** for "**Single-Conductor Cable**" simplified to now call for single-conductor cable in exposed outdoor locations in PV system dc circuits within the PV array to be either PV wire or cable or single-conductor cable marked sunlight resistant and Type USE-2 and Type RHW-2

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems *(cont.)*

- Revisions to **690.31** organized **PV wiring methods** into one section *(cont.)*
- **690.31(C)(2)** deals with single-conductor PV wire or cable installed in a cable tray with revision to this list item adding single-conductor **distributed generation (Type DG) cable** of all sizes to be permitted to be installed in a cable tray installed in outdoor locations *(with conditions)*
- **690.31(C)(3)** for multiconductor jacketed cables added new provisions for distributed generation (Type DG) cables
- Type DG cable is closely related to Type TC-ER, but it is better suited for the renewable energy and other distributed generation applications allowing for different variations in conductor combinations within a single jacket

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems *(cont.)*

- Revisions to **690.31** organized **PV wiring methods** into one section *(cont.)*
- **690.31(C)(4), (5), and (6)** were existing requirements moved from previous 690.31(E),(H), and (F) respectfully with no technical change to group all single-conductor cables requirements together at **690.31(C)**
- **690.31(D)** title was shortened to be more descriptive of what it covers *(Direct-Current Circuits on or in a Buildings) [was 690.31(G)]* and extensively revised
- **690.31(D)** generally requires PV system dc circuits run inside a building to be contained in a metallic wiring system
- Purpose of revision was to acknowledge that the **physical protection requirements** of **690.31(D)** are related to the ability to detect ground faults and to protect from contact with higher voltage cables

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems *(cont.)*

- Revisions to **690.31** organized **PV wiring methods** into one section *(cont.)*
- New **exception** was added for **690.31(D)** which addresses PV hazard control systems
- **Previous requirement at 690.31(G)(1)** that called for PV circuits that were embedded in built-up, laminate, or membrane roofing materials in roof areas *(not covered by PV modules and associated equipment)* to be clearly marked for its location has been **deleted** as these marking requirement referred to a wiring method that is no longer used *(embedded in building surfaces)*
- Revision also occurred at **690.31(D)(2)** ***(Marking and Labeling Required)*** by adding language to clarify that wiring methods need not be marked where their purpose is evident

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems *(cont.)*

- Revisions to **690.31** organized **PV wiring methods** into one section *(cont.)*
- **690.31(E)** titled, "**Bipolar Photovoltaic Systems**," *[was 690.31(I)]* received slight revision by replacing the term "monopole subarray" with the term "monopole circuit" as the reference is to the circuits to these monopole subarrays so the term "circuit" was added in all five locations where monopole subarray was previously used
- New **690.31(F)** added pertaining to roof-mounted PV array mounting systems and their wiring methods
  - Permits the roof-mounted PV array to be held in place with an **approved means** other than those required by 110.13 *(Mounting and Cooling of Equipment)*

690.31 Wiring Methods for Solar Photovoltaic (PV) Systems

690.31 was revised and re-organized for clarity and to bring PV wiring methods for PV source and output circuits to one location

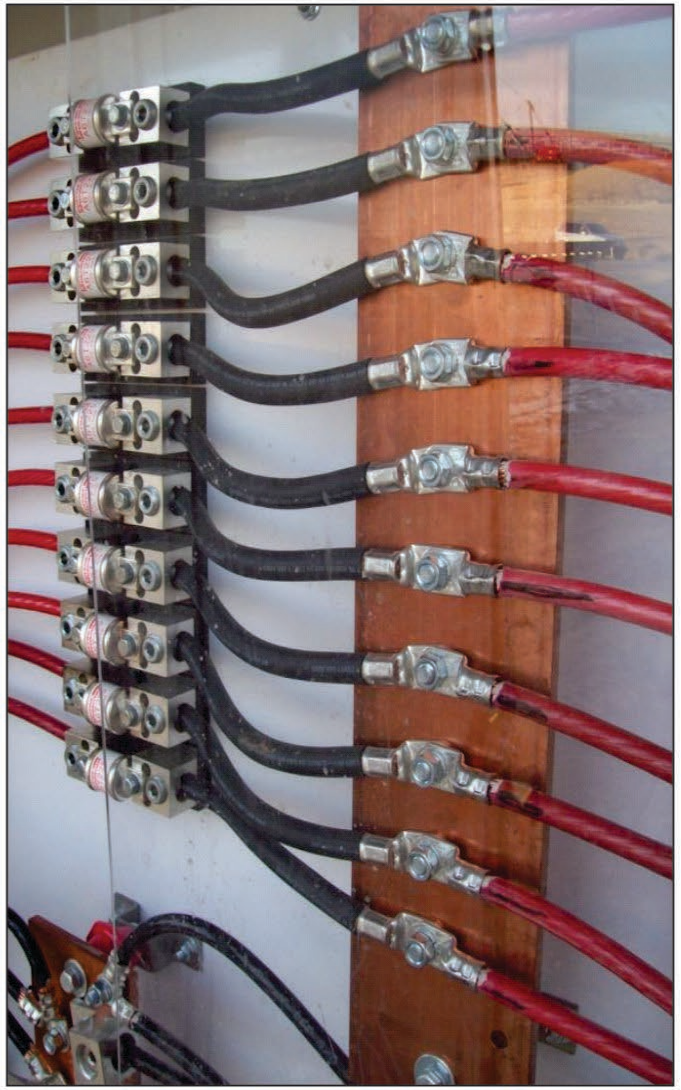
(A) Wiring Systems

(B) Identification and Grouping
- (1) Identification
- (2) Grouping

(C) Cables
- (1) Single-Conductor Cables
- (2) Cable Tray
- (3) Multiconductor Jacketed Cables
- (4) Flexible Cords and Cables Connected to Tracking PV Arrays
- (5) Flexible, Fine Stranded Cables
- (6) Small-Conductor Cables

(D) Direct-Cirrent on or in Buildings
- (1) Flexible Wiring Methods
- (2) Marking and labeling Required

(E) Bipolar Photovoltaic Systems



690.33 Mating Connectors Types for PV Systems

- New allowances added for mixing and matching brands of **PV mating connectors**
- Mating connectors **not of the identical type and brand** required to be "**listed and identified for intermatability**," as described in the manufacturer's instructions
- "**Intermatabilty**" is a term used in **UL 6703** (*Standard for Connectors for Use in Photovoltaic Systems)*
- Mating connectors required to be of the **latching or locking type** *(not new)*
- Mating connectors that are readily accessible and used in circuits operating at **over 30 volts dc or 15 volts ac** require a tool for opening *(not new)*
- Type of connector being described at 690.33 is clearly a mating connector, so the title of 690.33 was changed from "Connectors" to "**Mating Connectors**"
- Failures of connections made between mating connectors from different brands are well documented and represent a source of **electrical and fire hazard**

690.33(C) Mating Connector Types for PV Systems

Mating connectors shall be of the latching or locking type and where readily accessible and used in circuits operating at over 30 volts dc or 15 volts ac shall require a tool for opening

Mating connectors not of the identical type and brand are required to be “listed and identified for intermatability,” as described in the manufacturer's instructions

690.41(B) Ground-Fault Protection for PV Systems

- PV system dc circuits *(not just the arrays)* that exceed **30 volts** or **8 amperes** are now required to be provided with dc ground-fault protection (GFP)
- This section now consists of three subsections
  - (1) Ground-Fault Detection
  - (2) Faulted Circuits
  - (3) Indication of Faults (New)
- PV dc AFCI and GFP requirements in both **UL 1699-B** *[Standard for Photovoltaic (PV) DC Arc-Fault Circuit Protection]* and **IEC 62109-2** *(Safety of Power Converters for use in Photovoltaic Power Systems - Part 2)* acknowledge that only energy values above these levels pose an arcing or other fire risk

690.41(B) Ground-Fault Protection for PV Systems *(cont.)*

- PV system dc circuits *(not just the arrays)* that exceed **30 volts** or **8 amperes** are now required to be provided with dc ground-fault protection (GFP) *(cont.)*
- PV system circuits operating at lower voltage and power levels do not pose an arcing or other fire risk, therefore permitted to be installed **without GFP**
- Previous **exception** to **690.41(B)** permitted PV arrays with not more than two PV source circuits to be installed without GFP (where solidly grounded) as long as all PV system dc circuits were not on or in buildings has been reworded into positive language suitable for inclusion into the charging paragraph without changing the existing requirements
- New **informational note** has been added after the parent text of **690.41(B)** indicating that not all inverters, charge controllers, or dc-to-dc converters include GFP

690.41(B) Ground-Fault Protection for PV Systems *(cont.)*

- PV system dc circuits *(not just the arrays)* that exceed **30 volts** or **8 amperes** are now required to be provided with dc ground-fault protection (GFP) *(cont.)*
- Provisions for ground-fault detection at **690.41(B)(1)** have been revised to better align with the definitions in 690.2 and in particular, with the revised definition of "**Functionally Grounded**"
  - New language clarifies that either **GFP must be included in the converter**, or the converter and the equipment providing GFP must be **identified as being compatible** such that GFP of the circuit is maintained on either side of the converter
- Revised text at **690.41(B)(2)** concerning faulted circuits improves the application of these requirements to **any device providing GFP** *(not just inverters or charge controllers)* and clarifies the circuits to be controlled

690.41(B) Ground-Fault Protection for PV Systems *(cont.)*

- PV system dc circuits *(not just the arrays)* that exceed **30 volts** or **8 amperes** are now required to be provided with dc ground-fault protection (GFP) *(cont.)*
- Changes at **690.41(B)(2)** also better align *NEC* requirements with those found in PV GFP equipment safety standards such as **UL 1741** *(Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources)*
- New **690.41(B)(3)** added titled, "**Indication of Faults**" states that any GFP equipment must provide an "**indication of ground faults at a readily accessible location**"
- **UL 1741** requires inverters to "identify, interrupt, and provide an indication of ground faults"
- New **690.41(B)(3)** giving examples of **indication devices** such as remote indicator light, display, monitor, signal to a monitored alarm system, or receipt of notification by web-based services

GFP dc PV protection typically integral to the inverter

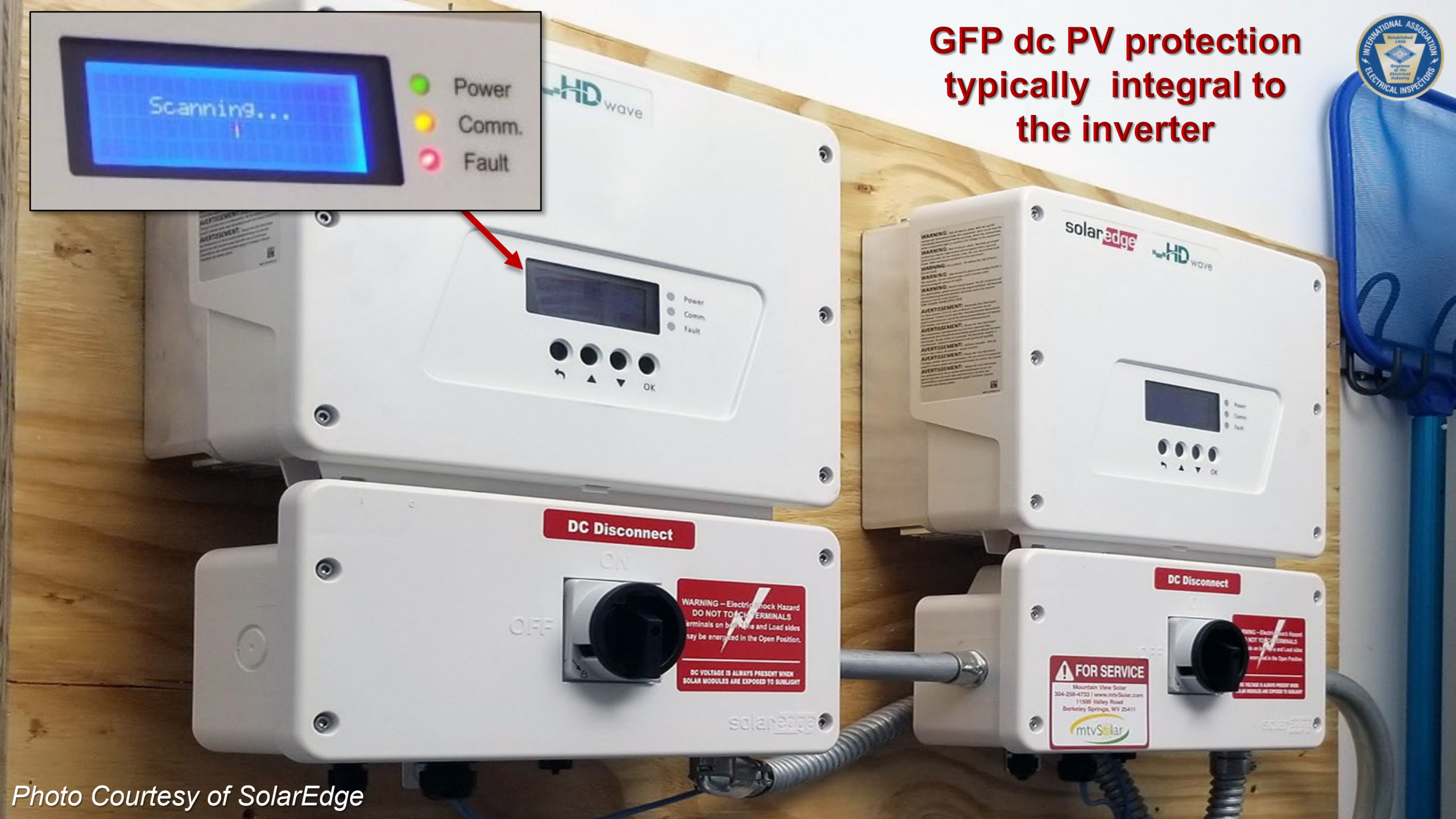
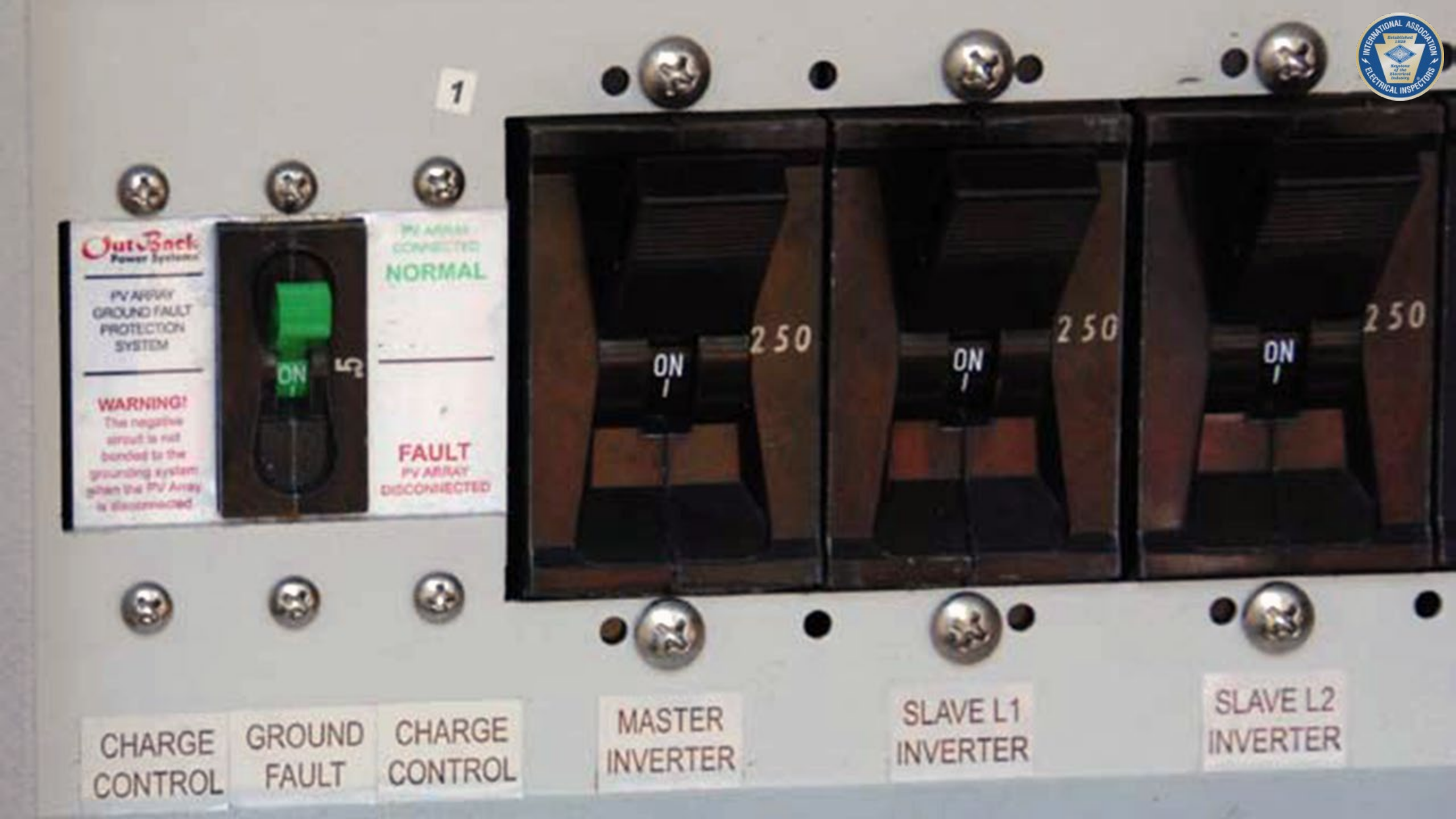


Photo Courtesy of SolarEdge

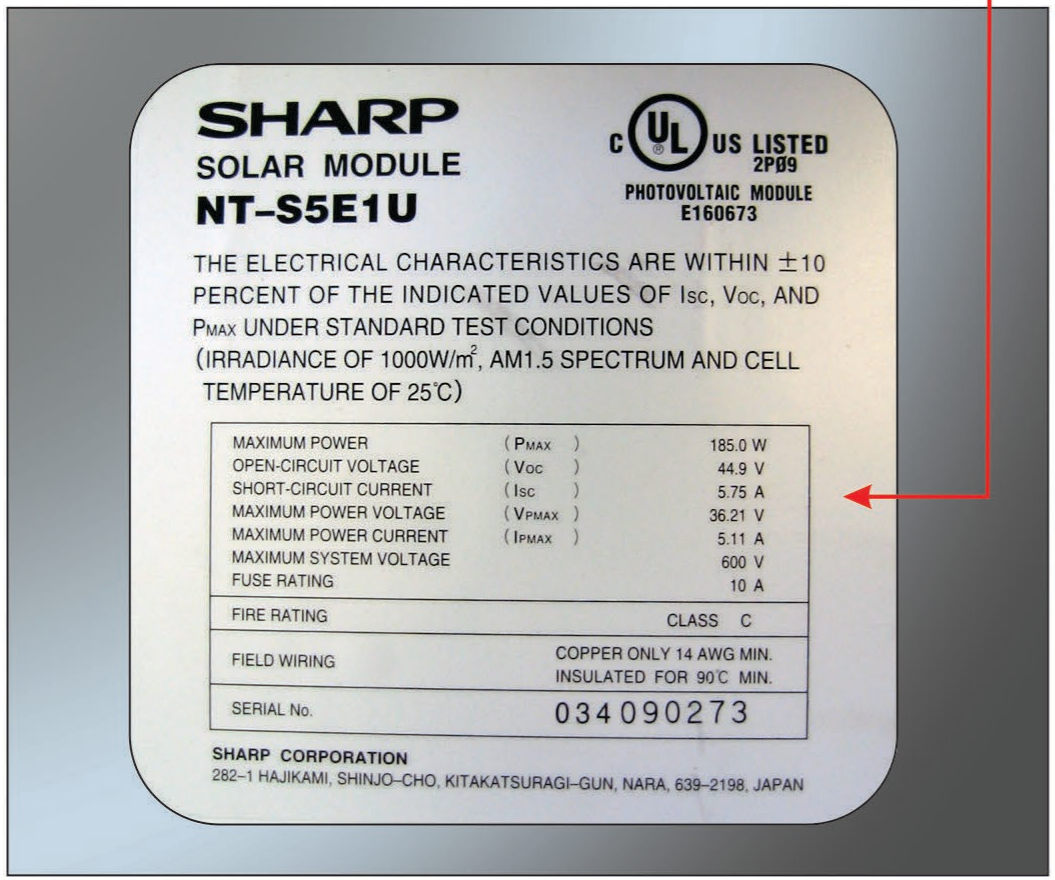

1
OutBack Power Systems
PV ARRAY GROUND FAULT PROTECTION SYSTEM
WARNING!
This negative circuit is not bonded to the grounding system when the PV Array is disconnected
ON
PV ARRAY CONNECTED
NORMAL
FAULT
PV ARRAY DISCONNECTED
ON
250
ON
250
ON
250
CHARGE CONTROL
GROUND FAULT
CHARGE CONTROL
MASTER INVERTER
SLAVE L1 INVERTER
SLAVE L2 INVERTER

690.51, ~~690.52~~, and 690.53 Marking Requirements of PV Modules and dc PV Circuits

- Information outlined at previous **690.51**, **690.52**, and **690.53** that is required as part of the listing requirement of this equipment has been deleted as it is being provided on the device by the manufacturer
- **690.51** revised to simply require modules and ac modules to be marked in accordance with their listing
- **Previous 690.52** was deleted entirely
- **690.53** was revised to require a permanent readily visible label indicating the highest maximum dc voltage in a PV system
- Desirable to remove these values from the required label in order to not inadvertently create conflict or confusion with any other required safety labeling such as may be required in Article 110

Marking Requirements for PV Modules and DC PV Circuits

Information outlined at previous 690.51, 690.52, and 690.53 that is required as part of the listing of this equipment has been deleted as it is being provided on the device by the manufacturer



A permanent readily visible label indicating the highest maximum dc voltage in a PV system is required by 690.53

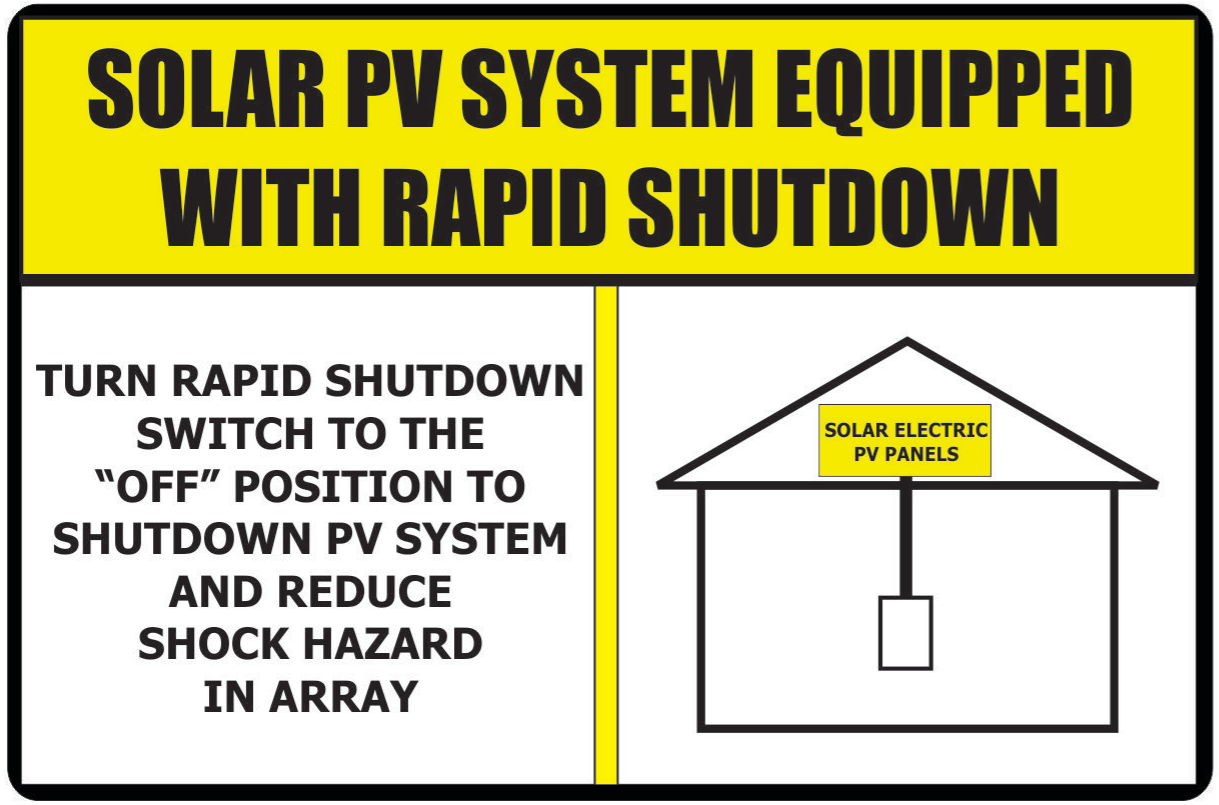
690.56(C) Identification of Power Sources for Buildings with Rapid Shutdown

- Several changes were made to **690.56(C)** to address the updated requirements in **690.12** *(Rapid Shutdown of PV Systems on Buildings)*
- Previous 690.56(C) contained **two figures** at 690.56(C)(1) illustrating labels required for the then two different types of rapid shutdown systems for a PV installation
- Remaining text of previous **690.56(C)(1)** has been changed to **remove** the option for the label and **previous Figure 690.56(C)(1)(b)**, previously listed under **690.56(C)(1)(b)**, since this label now describes a shutdown method that is no longer *Code* compliant
- The title of the remaining figure has been changed to identify this figure as an **informational note figure** to clarify that the label as shown is merely **an example** of a rapid shutdown system label

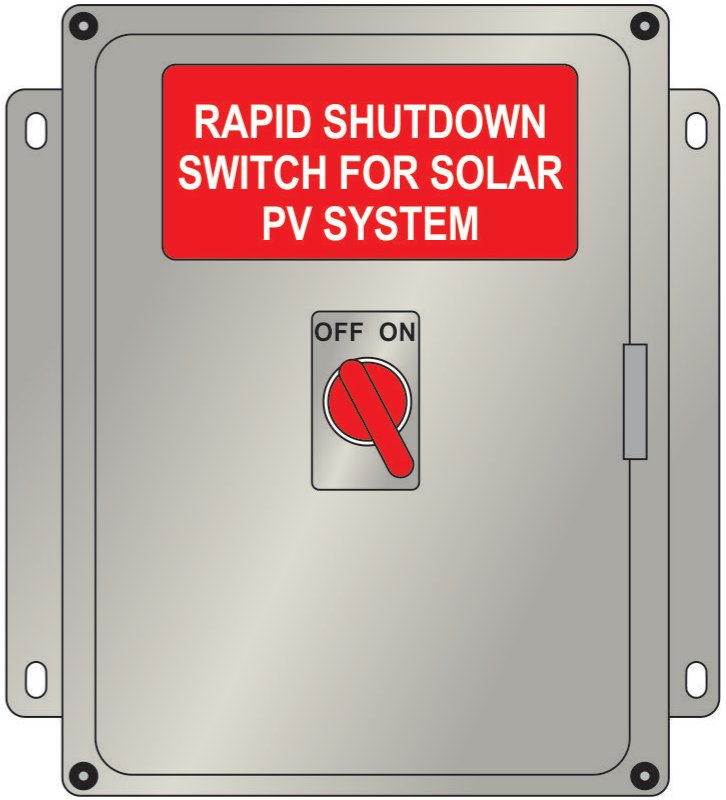
690.56(C) ID of Power Sources for Buildings with Rapid Shutdown

Buildings with PV systems shall have a permanent label located at each service equipment location to which the PV systems are connected or at an approved readily visible location and shall indicate the location of rapid shutdown initiation devices

Information Note Figure 690.56(C): Label for Roof-Mounted PV Systems with Rapid Shutdown



Label required by 690.56(C)(2)



Title of remaining figure has been changed to identify this figure as an informational note figure to clarify that the label as shown is merely an example of a rapid shutdown system label

691.1 Scope and I-Note Figure 691.1

- New **Informational Note No. 3** and **Informational Note Figure 691.1** were added to Article 691 as an aid in interpretation
- Title of **Article 691** was changed to "**Large-Scale Photovoltaic (PV) Electric Power Supply Stations**" with the **scope changed** to indicate that the article is intended to cover "the installation of large-scale PV electric supply stations with an inverter generating capacity of no less than 5000 kW, and not under exclusive utility control"
- Term "**supply station**" which was used 12 times throughout Article 691 in the 2017 *NEC* and 17 times in the 2020 *NEC*
- Utilizing the term "**supply station**" better aligns the *NEC* and **National Electrical Safety Code (NESC)** on this term, which is describing the same equipment set in both Codes

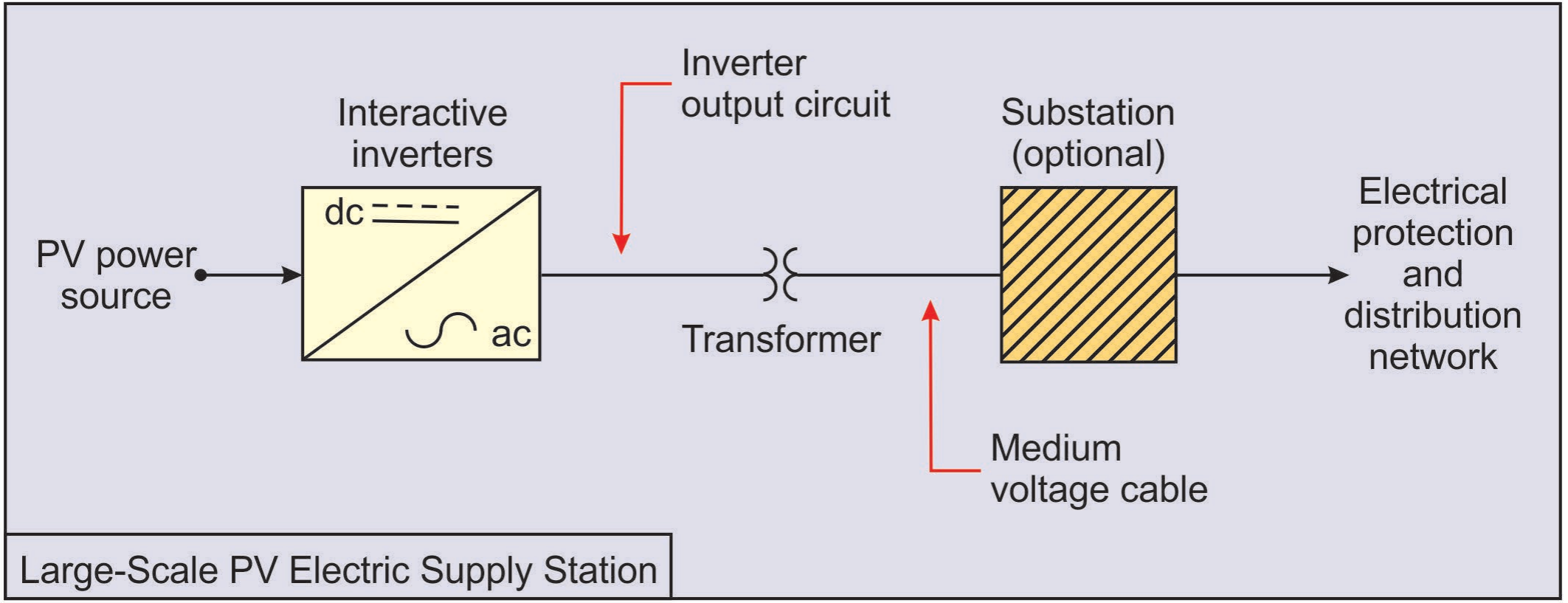
691.1 Scope and I-Note Figure 691.1 *(cont.)*

- New **Informational Note No. 3** and **Informational Note Figure 691.1** were added to Article 691 as an aid in interpretation *(cont.)*
- Scope of Article 691 was **updated** to align with the definition of "**Generating Capacity, Inverter**" located in Article 100
- This definitions states that Inverter Generating Capacity is defined as "the sum of parallel-connected inverter maximum continuous output power at 40°C in watts or kilowatts"
- **New informational note** was **added** after the scope of Article 691 directing users of the *Code* to a **new informational figure** intended to help in identification of unique system components related to large scale PV electrical supply stations

691.1 Scope and Informational Note Figure 691.1

This article covers the installation of large-scale PV electric ~~power production facilities with a~~ supply stations with an inverter generating capacity of no less than 5000 kW, and not under exclusive utility control.

Informational Note Figure 691.1: Large-Scale PV Electric Supply Station Components.



Notes:
(1) Custom designs occur in each configuration, and some components are optional.
(2) The drawing is for informational purposes only and is not representative of all potential configurations.

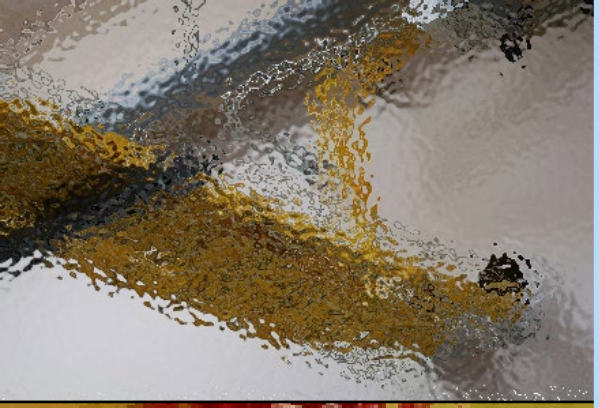
691.9 Disconnection Means for Isolating PV Equipment

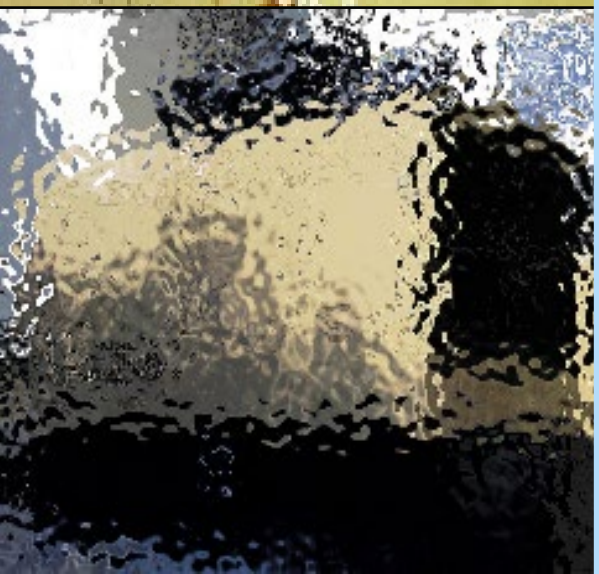
- **Title revised** to be consistent with usage in Article 690, particularly 690.15
- First sentence allowing isolating devices to be located remotely from equipment was revised to align more closely with the defined term "**In Sight From (Within Sight From, Within Sight)**" in Article 100
- Provisions requiring **written safety procedures** and conditions of maintenance and supervision ensuring that only **qualified persons** service the equipment was **deleted**
- New text added requiring **documentation** of the disconnection procedures and means of isolating equipment required by the engineered design of 691.6

691.9 Disconnection Means for Isolating Photovoltaic Equipment

Isolating devices not required within sight of equipment and permitted to be located remotely from equipment

Engineered design required by 691.6 shall document disconnection procedures and means of isolating equipment





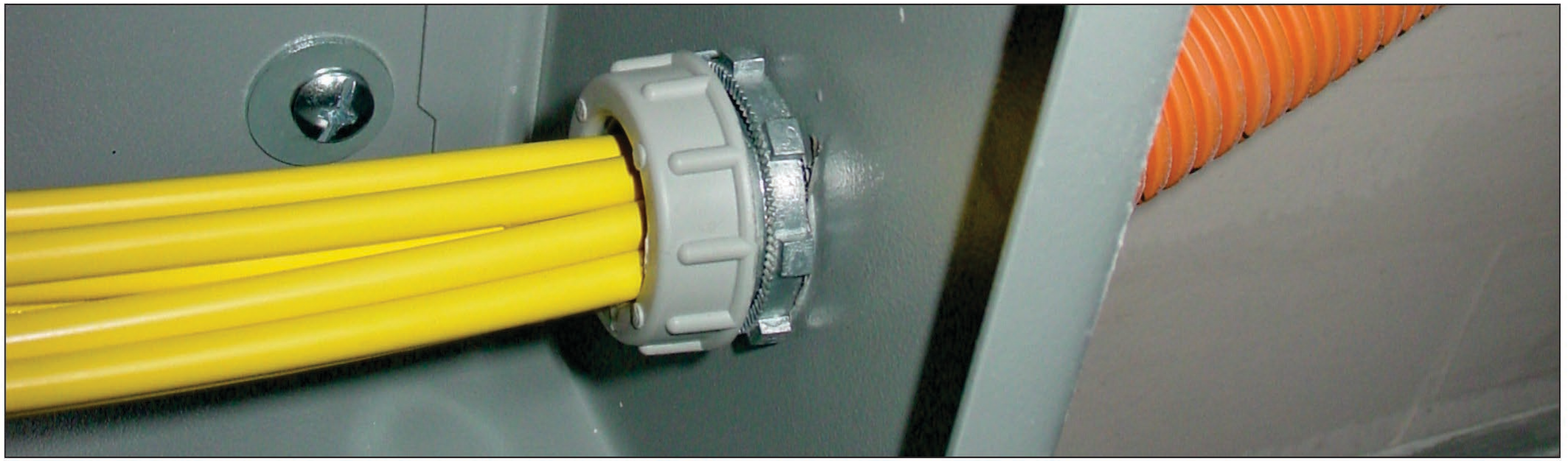
Chapter Seven Special Conditions

725.3(O) Temperature Limitation of Class 2 and Class 3 Cables

- New text clarifies that the **temperature limitations for conductors** of 310.14(A)(3) apply to Class 2 and Class 3 cables as well *(not just conductors)*
- New **725.3(O)** ***(Temperature Limitation of Class 2 and Class 3 Cables)*** states that requirements of **310.14(A)(3)** *[previous 310.15(A)(3)] (temperature limitation of conductors)* shall apply to Class 2 and Class 3 cables
- Because Class 2 and Class 3 circuits are typically installed in a cable rather than individual conductors, some argued that the temperature limitations of conductors of **310.14(A)(3)** did not apply to Class 2 and Class 3 cables
- To put this argument to rest, a new subsection was added to Article 725 at 725.3(O)
- Same change occurred at **760.3(N)** for **fire alarm system Class 2 and Class 3 cables**

725.3(O) Temperature Limitation of Class 2 and Class 3 Cables

The requirements of 310.14(A)(3) on the temperature limitation of conductors shall apply to Class 2 and Class 3 cables *(not just conductors)*

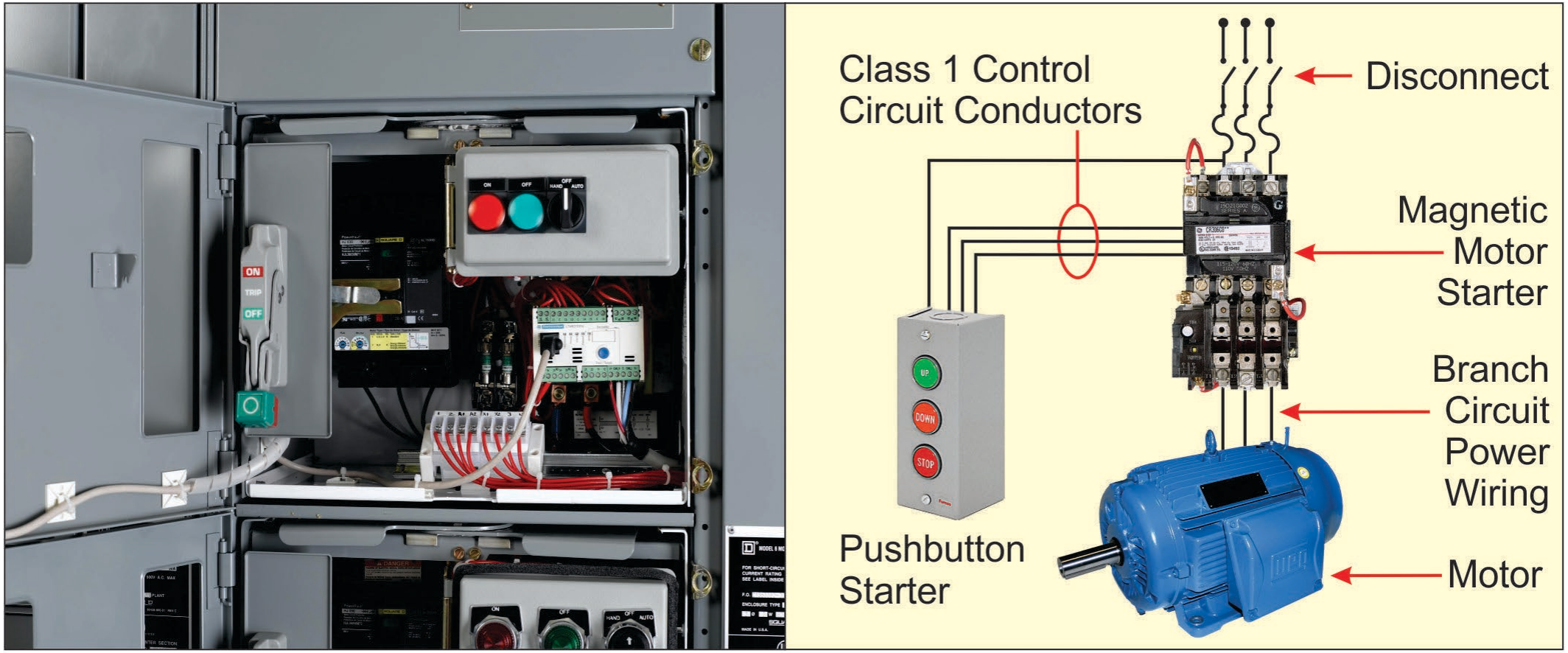


725.48(B)(1) Class 1 Circuits with Power-Supply Circuits

- Revision permits **Class 1 circuits** to share enclosure space with conductors of electric light, power, non–power-limited fire alarm and medium power network-powered broadband communications circuits as long as separated by a **barrier**
- Previously, Class 1 circuits and power-supply circuits were only permitted to occupy the same cable, enclosure, or raceway ***without a barrier*** only where the equipment powered was ***functionally associated*** *(still applies)*
- The “barrier” requirement for Class 1, Class 2, and Class 3 circuits is not specific as to the type of material required

725.48(B)(1) Class 1 Circuits with Power-Supply Circuits

Class 1 circuits and power-supply circuits permitted to occupy the same cable, enclosure, or raceway without a barrier only where the equipment powered is functionally associated



Class 1 circuits permitted to be installed with conductors of electric light, power, non-power-limited fire alarm, etc. *where separated by a barrier*

725.144 and Table 725.144 Transmission of Power and Data

- Extensive revision occurred for 725.144, Table 725.144, 725.144(A), and 725.144(B) dealing with **transmission of power and data** on Class 2, Class 3, Class 2-LP, or Class 3-LP cables
- Requirements of parent text of 725.144 did not change, just revised for clarity
- New ***Informational Note No. 3 and No. 4*** were added to identify the unique nature of the type of conductors and cables specified at Table 725.144 and to provide the appropriate reference standards that address the cables covered in the Table
- New ***Informational Note No. 5*** was added since Power over Ethernet (PoE) lighting is a very important application covered by 725.144

725.144 and Table 725.144 Transmission of Power and Data *(cont.)*

- Extensive revision occurred for 725.144, Table 725.144, 725.144(A), and 725.144(B) dealing with **transmission of power and data** on Class 2, Class 3, Class 2-LP, or Class 3-LP cables *(cont.)*
- New ***Informational Note No. 6*** was added to clarify that the rated current for power sources covered in 725.144 is the output current per conductor the power source is designed to deliver to an operational load at normal operating conditions, as declared by the manufacturer
- At Table 725.144, the undefined term “Data Cables” has been replaced with “**Balanced Twisted-Pair Cables**,” which is language that is consistent with relevant industry standards *(such as **ANSI/TIA-568-C.2-2009** Balanced Twisted-Pair Telecommunications Cabling and Components Standards)* and is also consistent with language in other parts of Article 725

725.144 and Table 725.144 Transmission of Power and Data *(cont.)*

- Extensive revision occurred for 725.144, Table 725.144, 725.144(A), and 725.144(B) dealing with **transmission of power and data** on Class 2, Class 3, Class 2-LP, or Class 3-LP cables *(cont.)*
- All the ampacity adjustment factors in **previous Table 725.144** were expressed to **one tenth values** *(i.e. 1.4, 1.7. 0.6, etc.)* except for the ampacity adjustment factors of whole numbers, such as “1, 2 and 3” amperes
- Based on **Note 2 to the table**, an ampacity of 1 ampere could be interpreted to be 1.4 amperes as this note states that where only half of the conductors in each cable are carrying current, the values in the table are permitted to be increased by a factor of 1.4
- The table ampacity adjustment factors of “1, 2 and 3” needed to be revised to “1.00, 2.00 and 3.00” respectively to avoid incorrectly interpreting these numbers

725.144 and Table 725.144 Transmission of Power and Data *(cont.)*

- Extensive revision occurred for 725.144, Table 725.144, 725.144(A), and 725.144(B) dealing with **transmission of power and data** on Class 2, Class 3, Class 2-LP, or Class 3-LP cables *(cont.)*
- **Table 725.144** ampacity adjustment factors are now expressed in double digit values
- Some of the ampacity values have been updated in **Table 725.144** to reflect new ampacity values for 23 AWG cables after recreating and reaffirming the data from the substantiation that generated this table in the 2017 *NEC*
- **725.144(A)**, covering the use of Class 2 or Class 3 cables to transmit power and data was **revised** to enhance the usability of this subsection by identifying applications where Table 725.144 need not be consulted

725.144 and Table 725.144 Transmission of Power and Data *(cont.)*

- Extensive revision occurred for 725.144, Table 725.144, 725.144(A), and 725.144(B) dealing with **transmission of power and data** on Class 2, Class 3, Class 2-LP, or Class 3-LP cables *(cont.)*
- The requirements of **725.144(B)**, titled "**Use of Class 2-LP or Class 3-LP Cables to Transmit Power and Data**" was revised with a new sentence added pertaining to **bundled LP cables**
- **725.144(B)** now states that where bundled LP cables number **192 or less** and the selected ampacity of the cables in accordance with Table 725.144 exceeds the marked current limit of the cable, the ampacity determined from the table is permitted to be used

Table 725.144

Table 725.144 Ampacities of Each Conductor in Amperes in 4-Pair Class 2 or Class 3 ~~Data~~ Balanced Twisted-Pair Cables Based on Copper Conductors at an Ambient Temperature of 30°C (86° F) with All Conductors in All Cables Carrying Current, 60°C (140°F), 75°C (167°F), and 90°C (194°F) Rated Cables

	Number of 4-Pair Cables in a Bundle																	
	1-7			8-19			20-37			38-61			62-91			92-192		
	Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating		
AWG	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C
26	1.00	1.23	1.42	0.71	0.87	1.02	0.55	0.68	0.78	0.46	0.57	0.67	0.45	0.55	0.64	N/A	N/A	N/A
24	1.19	1.46	1.69	0.81	1.01	1.17	0.63	0.78	0.91	0.55	0.67	0.78	0.46	0.56	0.65	0.40	0.48	0.55
23	1.24	1.53	1.78	0.89	1.11	1.28	0.77	0.95	1.10	0.66	0.80	0.93	0.58	0.71	0.82	0.45	0.55	0.63
22	1.50	1.86	2.16	1.04	1.28	1.49	0.77	0.95	1.11	0.66	0.82	0.96	0.62	0.77	0.89	0.53	0.63	0.72

Note 1: For bundle sizes over 192 cables, or for conductor sizes smaller than 26 AWG, ampacities shall be permitted to be determined by qualified personnel under engineering supervision.

Note 2: Where only half of the conductors in each cable are carrying current, the values in the table shall be permitted to be increased by a factor of 1.4.

Informational Note No. 1: Elevated cable temperatures can reduce a cable's data transmission performance. For information on practices for 4-pair balanced twisted pair cabling, see TIA-TSB-184-A and 6.4.7, 6.6.3, and Annex G of ANSI/TIA-568-C.2, which provide guidance on adjustments for operating temperatures between 20°C and 60°C.

Informational Note No. 2: The per-contact current rating of connectors can limit the maximum allowable current below the ampacity shown in Table 725.144.

760.121(B) Power Sources for PLFA Circuits *(Fire Alarm Systems)*

- New sentence added to permit the fire alarm branch-circuit disconnecting means for power limited fire alarm (PLFA) circuits to be **secured in the "on" position**
- The fire alarm circuit disconnect for non-power-limited fire alarm (NPLFA) circuits was already permitted to be secured in the "on" position *[see 760.41(A)]*
- Change provides consistency with NPLFA circuits and PLFA circuits
- While this practice was not prohibited by **760.121**, it was not specifically permitted either
- Installing **breaker locks** is already a common industry practice on fire alarm circuits


FIRE
ALARM
CIRCUIT
OFF
15
15A
15A

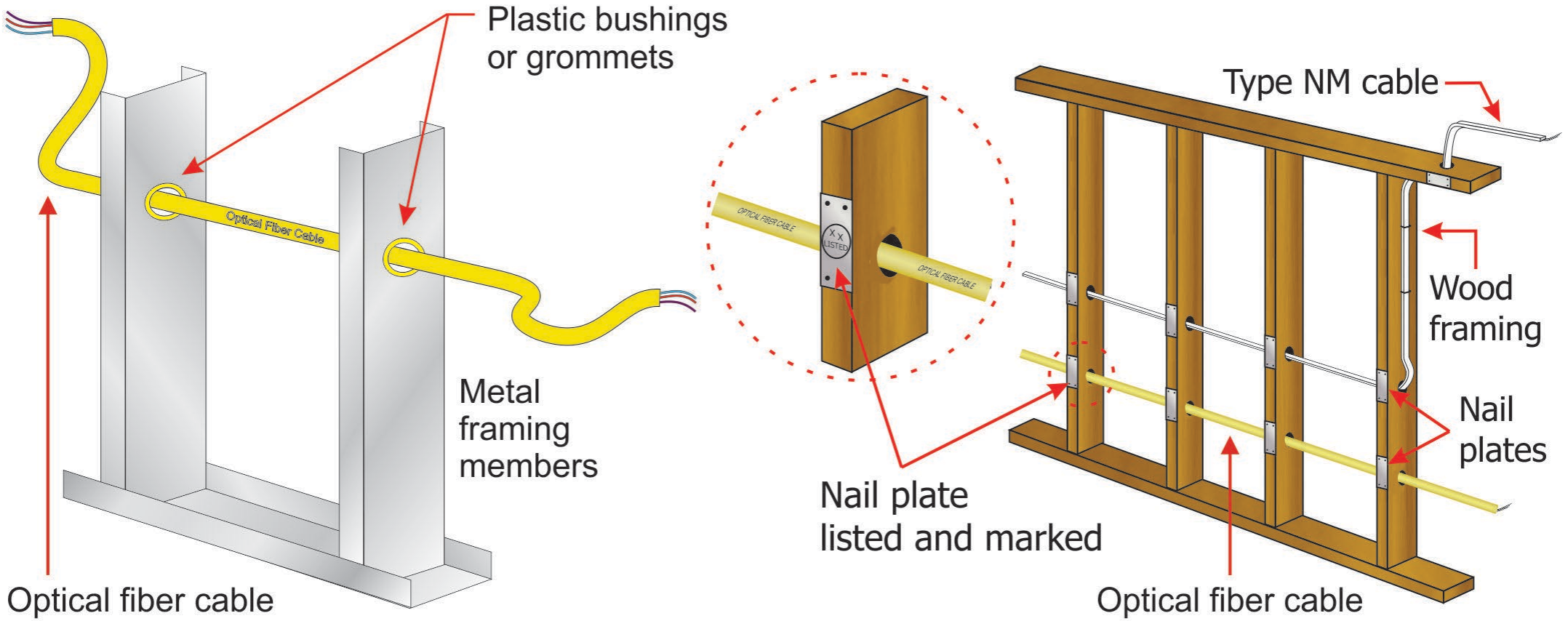
Courtesy of TC Life Safety

770.24 Mechanical Execution of Work (Optical Fiber Cable)

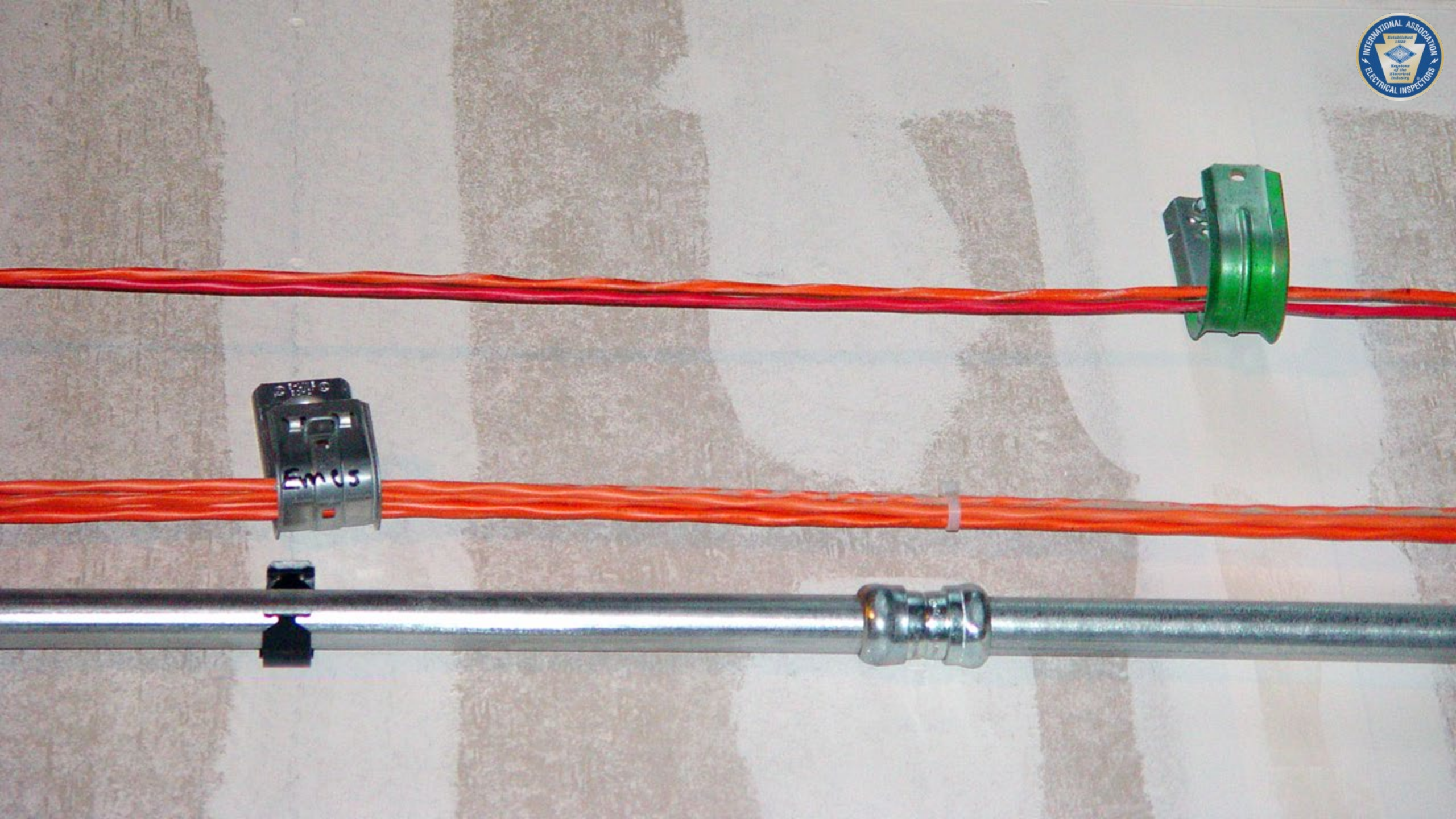
- Revision will require optical fiber cable to conform to **all of 300.4 and 300.11** *[not just 300.4(D) through (G)]*
- Previously, optical fiber cables were to be installed and protected from physical damage in accordance with 300.4(D) through (G) and 300.11
- Optical fiber cables not limited to communications installations and need protection against physical damage regardless if they can be a shock hazard or not
- Even if optical fiber cable is not carrying any current, the equipment being supplied by this cable in several situations are critical to **life and safety**
- The installation of these optical fiber cables should conform to **all of 300.4**

770.24 Mechanical Execution of Work for Optical Fiber Cable

Optical fiber cables are now required to be installed and protected from physical damage in accordance with all of 300.4 and 300.11 *[not just 300.4(D) through (G)]*



Where driven nails or screws can penetrate optical fiber cable installed through wood or metal studs, a steel sleeve, steel nail plate or steel clip not less than 1.6 mm (1/16 in.) in thickness is required to be installed *(Thinner steel plates permitted if listed and marked)*



770.110(D) Cable Trays for Optical Fiber Cables

- New section added permitting **optical fiber cables** to be installed in metal or listed nonmetallic **cable tray systems**
- Previously, permission to install optical fiber cable in a cable tray was given in several locations across Article 770
- This revision will make it easier to find this cable tray rule with it located in the same section that permits optical fiber cables to be installed in raceways and cable routing assemblies
- New requirement limits the allowance for optical fiber cables to be installed in a cable tray to **metal and listed nonmetallic cable trays** in order to address flame spread concerns
- Same change occurred for **communications cables and raceways** at **800.110(D)**


INTERNATIONAL ASSOCIATION
ELECTRICAL INSPECTORS

770.133 Installation of Optical Fibers and Electrical Conductors

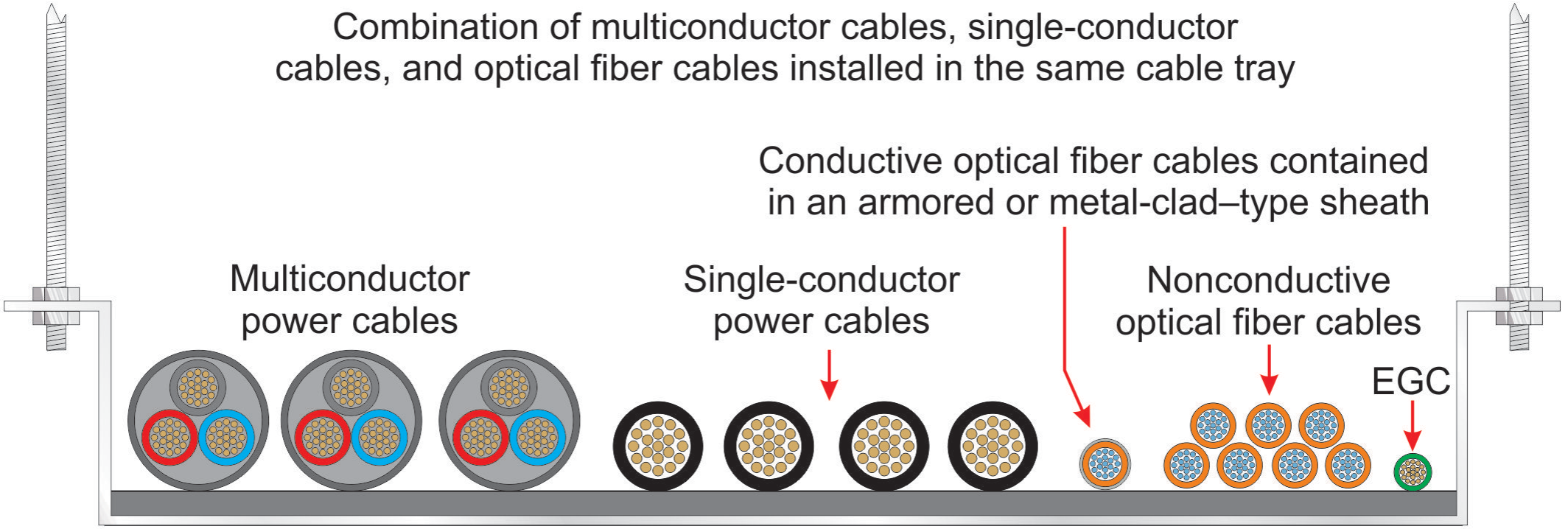
- Previous requirements of **770.133(A)** has been reorganized and relocated throughout **770.133(A)** and new **770.133(B)**
- Previous exceptions rewritten into positive *Code* language
- Previous 770.133(A) permitted optical fiber cables to occupy the same cable tray and raceway as conductors for electric light, power, Class 1, non-power-limited fire alarm, etc. *(with five exceptions)*
- Almost all of the 2017 *NEC* requirements of 770.133 are still there for the 2020 *NEC* but **relocated for a better flow of the information**
- Permission to allow nonconductive optical fiber cables to occupy the same cable tray as conductors for electric light, power, Class 1, non-power-limited fire alarm, etc. operating at 1000 volts or less was moved to the second paragraph of new 770.133(B)

770.133 Installation of Optical Fibers and Electrical Conductors *(cont.)*

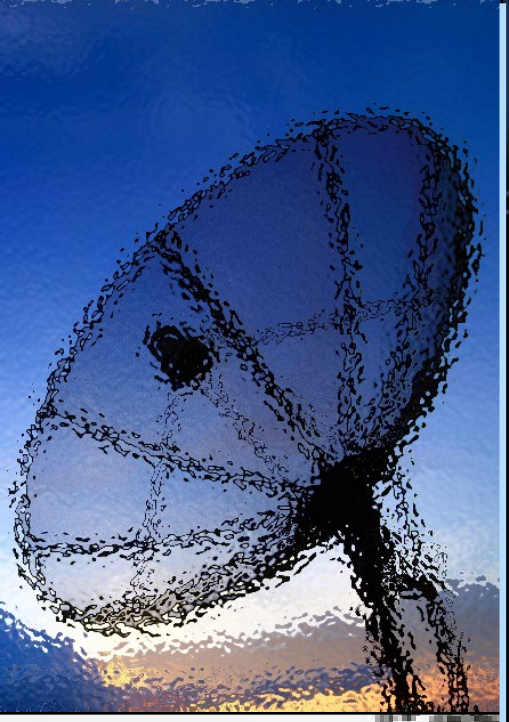
- Previous requirements of **770.133(A)** has been reorganized and relocated throughout **770.133(A)** and new **770.133(B)** *(cont.)*
- First paragraph of **770.133(A)** was updated to permit **conductive optical fiber cables** contained in an armored or metal-clad-type sheath and **nonconductive optical fiber cables** to occupy the same cable tray with conductors for electric light, power, Class 1, non-power-limited fire alarm, etc. operating at 1000 volts or less
- **Conductive optical fiber cables without an armored or metal-clad-type sheath** not permitted to occupy the same cable tray as power conductors, etc. unless separated by a **permanent barrier** or listed divider

770.133 Installation of Optical Fibers and Electrical Conductors

Optical fiber cables permitted to occupy the same cable tray and raceway *(with conditions)* as conductors for electric light, power, Class 1, non-power-limited fire alarm, etc. *(information reorganized for 2020 NEC)*



Conductive optical fiber cables contained in an armored or metal-clad–type sheath and non-conductive optical fiber cables shall be permitted to occupy the same cable tray or raceway with conductors for electric light, power, Class 1, non–power-limited fire alarm, etc.



Chapter Eight Communications Systems

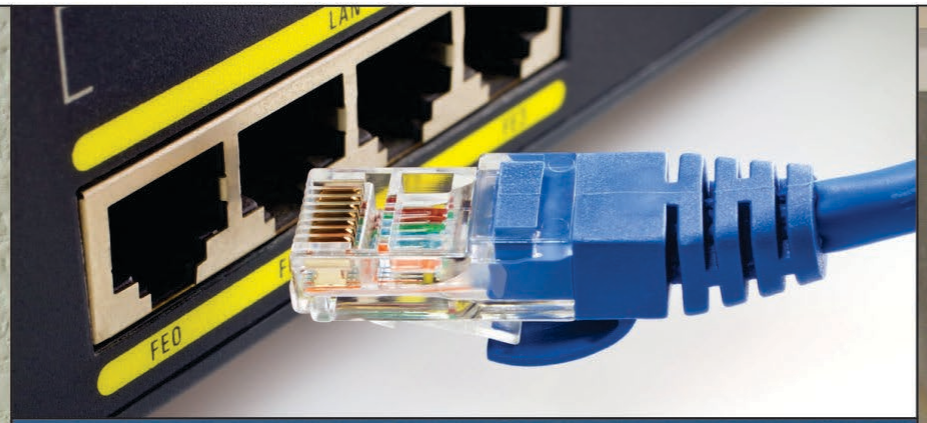
Stopped Here

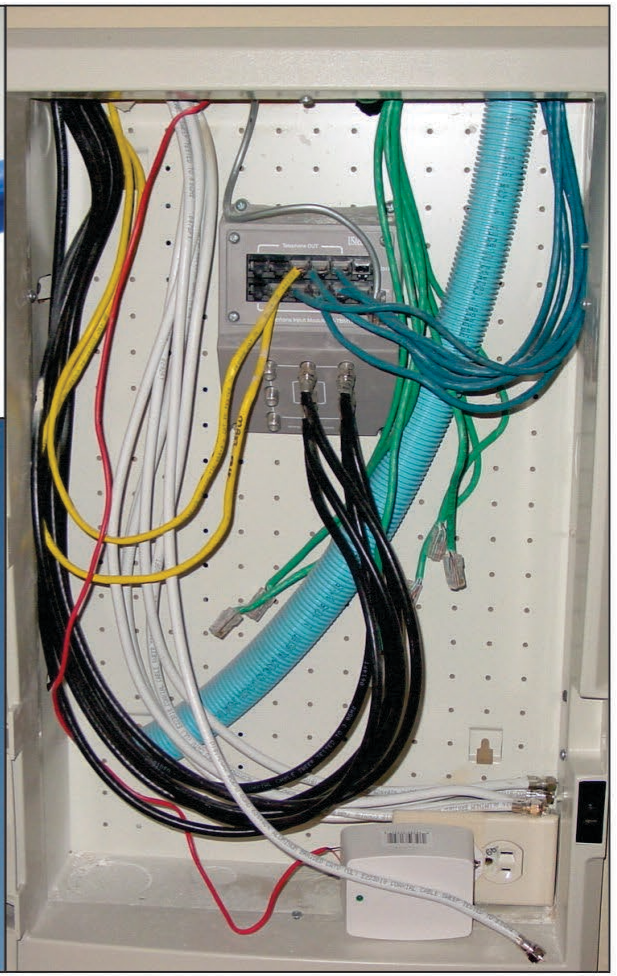
Article 800 General Requirements for Communications Systems

- **New Article 800** *(General Requirements for Communications Systems)* combines **common requirements** previously found in Articles 800, 820, 830 and 840 into a **new "general" article** that applies to all of these articles
- **Previous Article 800** *(Communications Circuits)* was moved to **Article 805** to make room for this new Chapter 8 article
- **Common requirements** would include such things as mechanical execution of work, abandoned cables, spread of fire or products of combustion, and temperature limitations of wires and cables
- In previous editions of the *Code*, if a change in one of the Chapter 8 articles occurred, it was a good bet that the same change would be occurring in the other Chapter 8 articles as well
- New article for communication circuits significantly improves clarity and usability while removing redundant requirements from each of the articles throughout Chapter 8

Article 800 General Requirements for Communications Systems

800.1 Scope. This article covers general requirements for communications systems. These general requirements apply to communication circuits, and equipment community antenna television and radio distribution systems, network-powered broadband communication systems, and premises-powered broadband communication systems unless modified by Articles 805, 820, 830, or 840.





800.2 Definitions: Communications Circuit

- **Communications Circuit.** The circuit that extends service from the communications utility or service provider to and including the customer's communications equipment.
- The definition of a "**Communications Circuit**" was revised to remove the "list" of service types offered by a communications circuit
- List was problematic as it did not allow for new technologies to be included in this definition without a *Code* change, which only happens every three years


AT&T
WARNING
CALL 811

800.3 Other Articles for Communications Systems

- New text was added to reinforce the **independence of Article 800 and Chapter 8** which stipulates that only those sections of Chapters 1 through 7 referenced in Article 800 shall apply to communications systems
- Opening sentence of 800.3 now reads, "**Only those sections of Chapters 1 through 7 referenced in Chapter 8 shall apply to Chapter 8**."
- Requirements of **90.3** state that Chapter 8 of the *NEC* is a **"stand-alone" article** and "is not subject to the requirements of Chapters 1 through 7 except where the requirements are specifically referenced in Chapter 8"
- In order for a requirement from Chapters 1 through 7 to apply to Chapter 8, there must be a clear reference or "**road map**" in Chapter 8 to a specific requirement in Chapters 1 through 7

800.3 Other Articles for Communications Systems

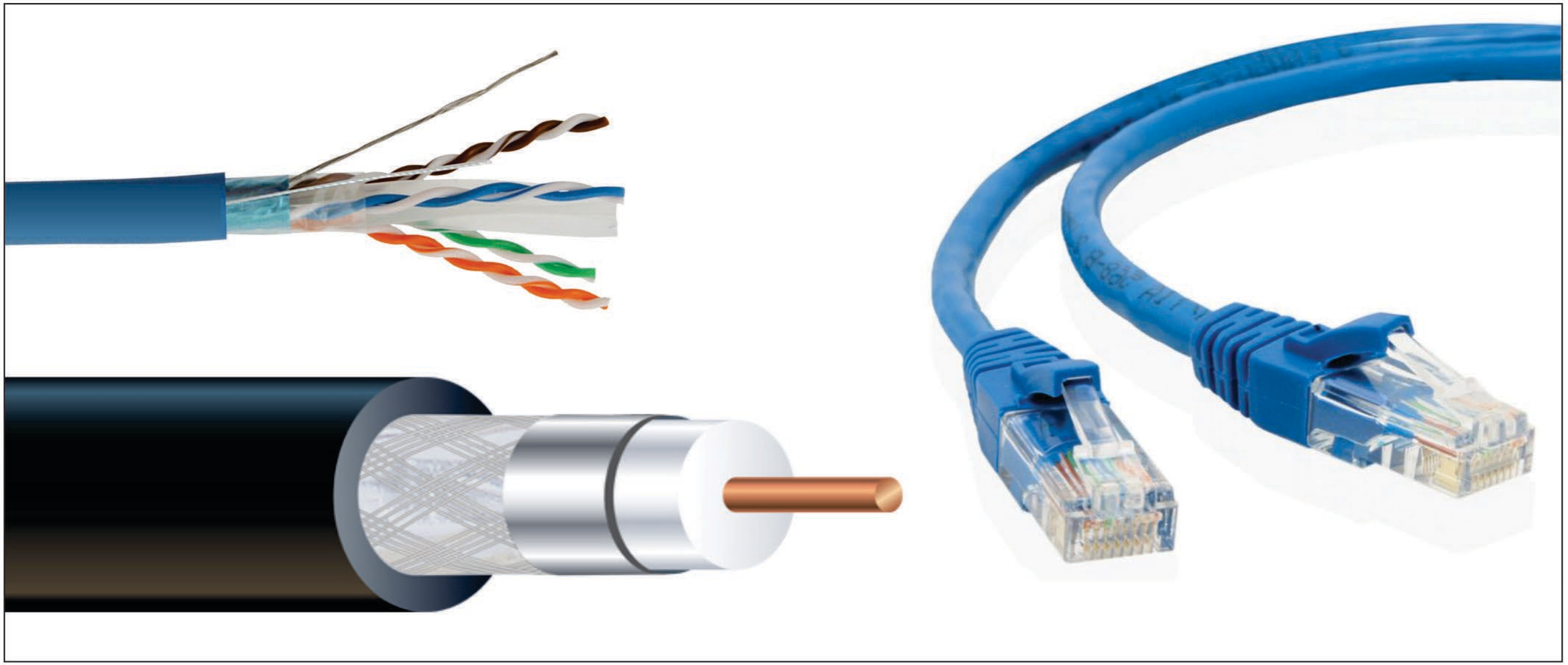
Only those sections of Chapters 1 through 7 referenced in Chapter 8 shall apply to Chapter 8

800.27 Temperature Limitation of Wire and Cables (Communications Systems)

- New section added to specify that no communication wire or cable be used in such a manner that its **operating temperature** exceeds that of its rating
- When the previous requirements of 800.3 were moved to new Article 800, it was felt that this **temperature limitation requirement** deserved its own section in Article 800
- Previous temperature limitations of 800.3(H) were moved to a **new 800.27** and titled "**Temperature Limitation of Wires and Cables**"
- New text at 800.27 makes it clear that this temperature limitations in Chapter 8 **apply to cables** *(not just conductors)*
- New text simplifies the *Code* by including the temperature limitation requirement **directly in Article 800**, rather than have a cross-reference in Article 800 to the temperature limitation requirements of **Article 310**

800.27 Temperature Limitation of Wire and Cables *(Communications Systems)*

No communications wire or cable is permitted to be used in such a manner that its operating temperature exceeds that of its rating



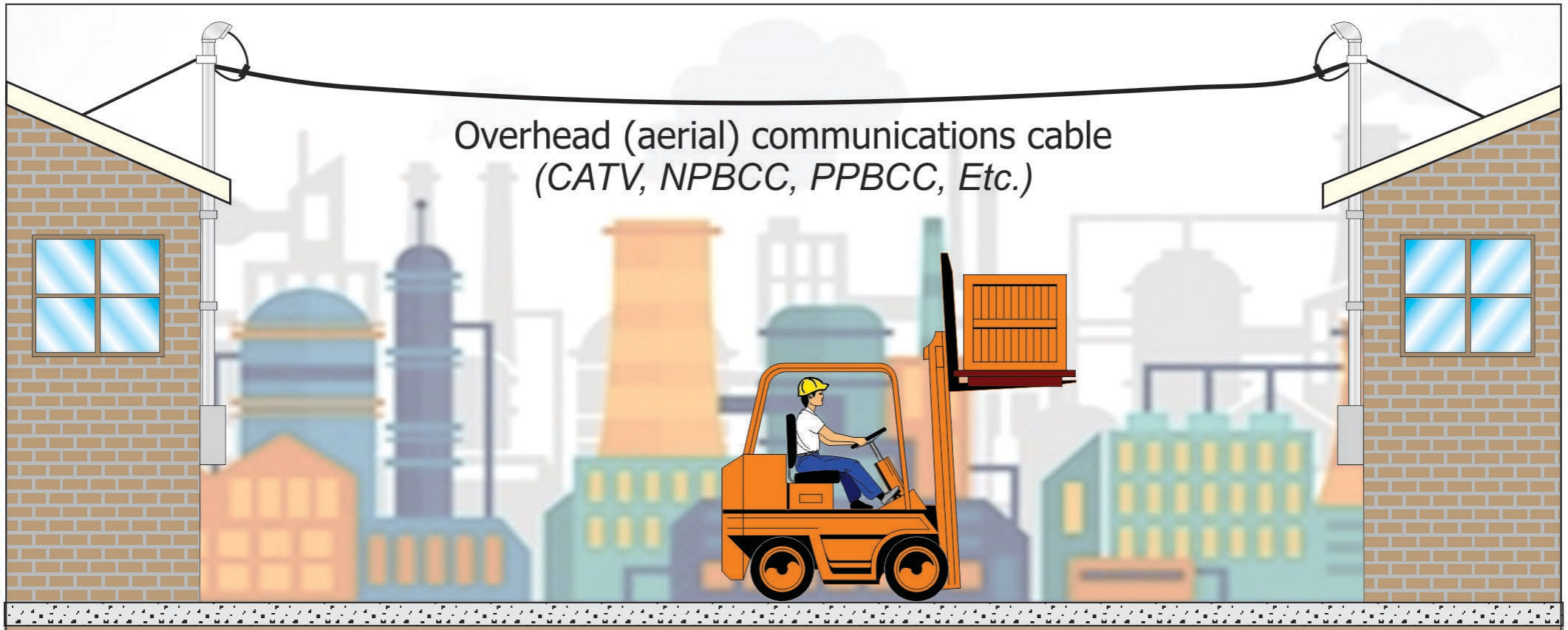
Plenum, riser, general-purpose, and limited-use communications cables required to have a temperature rating of not less than 60°C (140°F) *(see 800.179)*

800.44 Overhead (Aerial) Communications Wires and Cables

- Requirements were added for ***all*** communications circuits pertaining attachment to **above-the-roof raceway mast** and cables extending between buildings or structures
- Previously, **Article 820** contained provisions for attaching coaxial cables to an **above-the-roof raceway mast** that did not enclose or support conductors of electric light or power circuits *(none of the other Chapter 8 article contained this mast rule)*
- Previously, **Articles 820 and 830** contained requirements pertaining to coaxial cables and network-powered broadband communications **cables extending between buildings** or structures *(other Chapter 8 articles did not have such rules)*
- These two rules were perfect candidates to be placed in **new Article 800** to prevent repeating these rules in four different articles *(needed consistency)*

800.44 Overhead (Aerial) Communications Wires and Cables

Overhead (aerial) communications and CATV type coaxial cables permitted to be attached to above-the-roof raceway mast that does not enclose or support conductors of electric light or power circuits



Communications and CATV type coaxial cables extending between buildings or structures *(along with the supports or attachment fixtures)* shall be identified and shall have sufficient strength to withstand the loads to which they might be subjected *(Ex. for supporting messenger cable)*

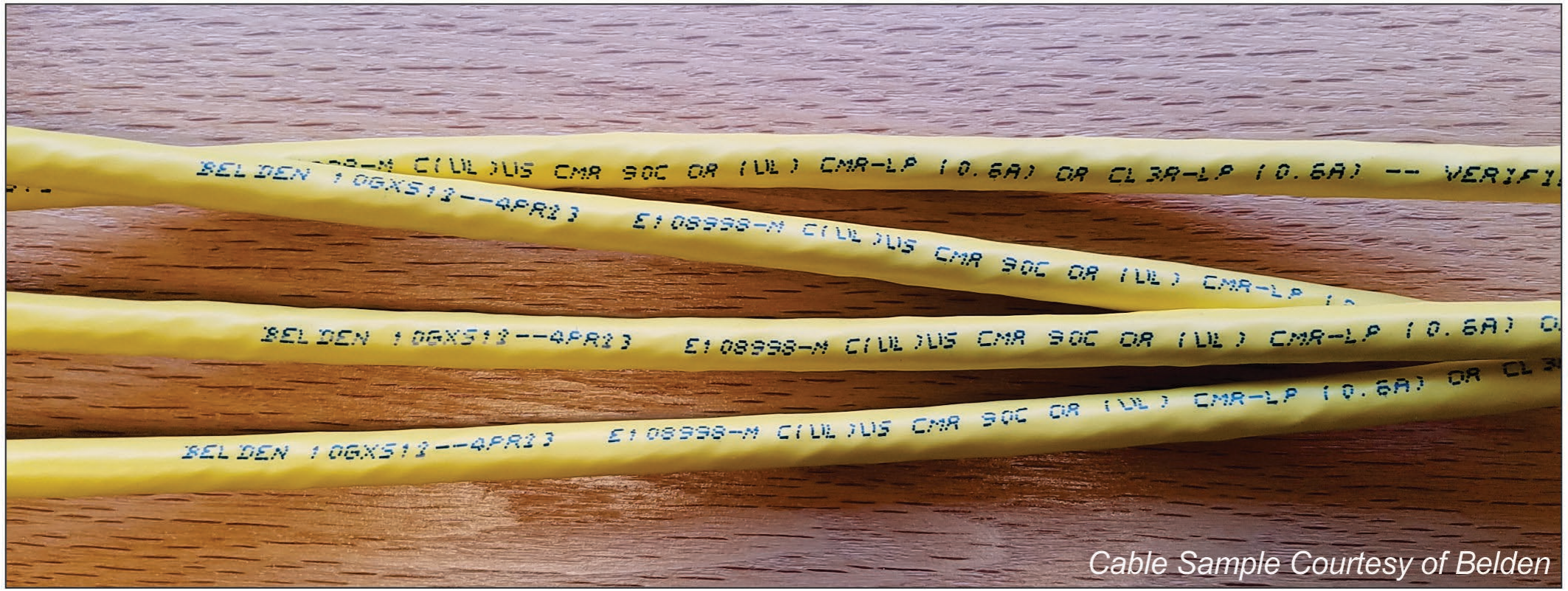
805.179(D) Limited Power (LP) Cables

- Provisions were added to permit **limited power (LP) cables** to act as a **substitute** for Class 2 and Class 3 cables
- Previously, communications cables were permitted as substitutes for Class 2 and Class 3 cables, but the *Code* **did not specifically address** limited power (LP) cables as a substitute for Class 2 and Class 3 cables
- **725.144** and **Table 725.144** gives designers, installers and AHJs the assurance that 4-pair data cables can safely carry power as well as data when bundled together in cable trays or cable routing assemblies
- This revision recognizes the fact that an **LP cable** is a specific type of Class 2, Class 3, and communications cable and explicitly permits these cable types as **substitutes** for Class 2 and Class 3 LP cables *(vast majority of LP cables are listed as communications cables)*
- LP cables are listed under the UL product categories of Communications Cable **(DUZX)** and Power Limited Circuit Cable **(QPTZ)**

805.179(D) Limited Power (LP) Cables

Provisions added at to permit limited power (LP) cables to act as a substitute for Class 2 and Class 3 cables as well as the previous provisions allowing communications cables as substitutes for Class 2 and Class 3 cables

CMR-LP (0.6A) (75C) 23 AWG 4 pair



Cable Sample Courtesy of Belden

840.2 Definitions for Premises-Powered Broadband Communications Systems

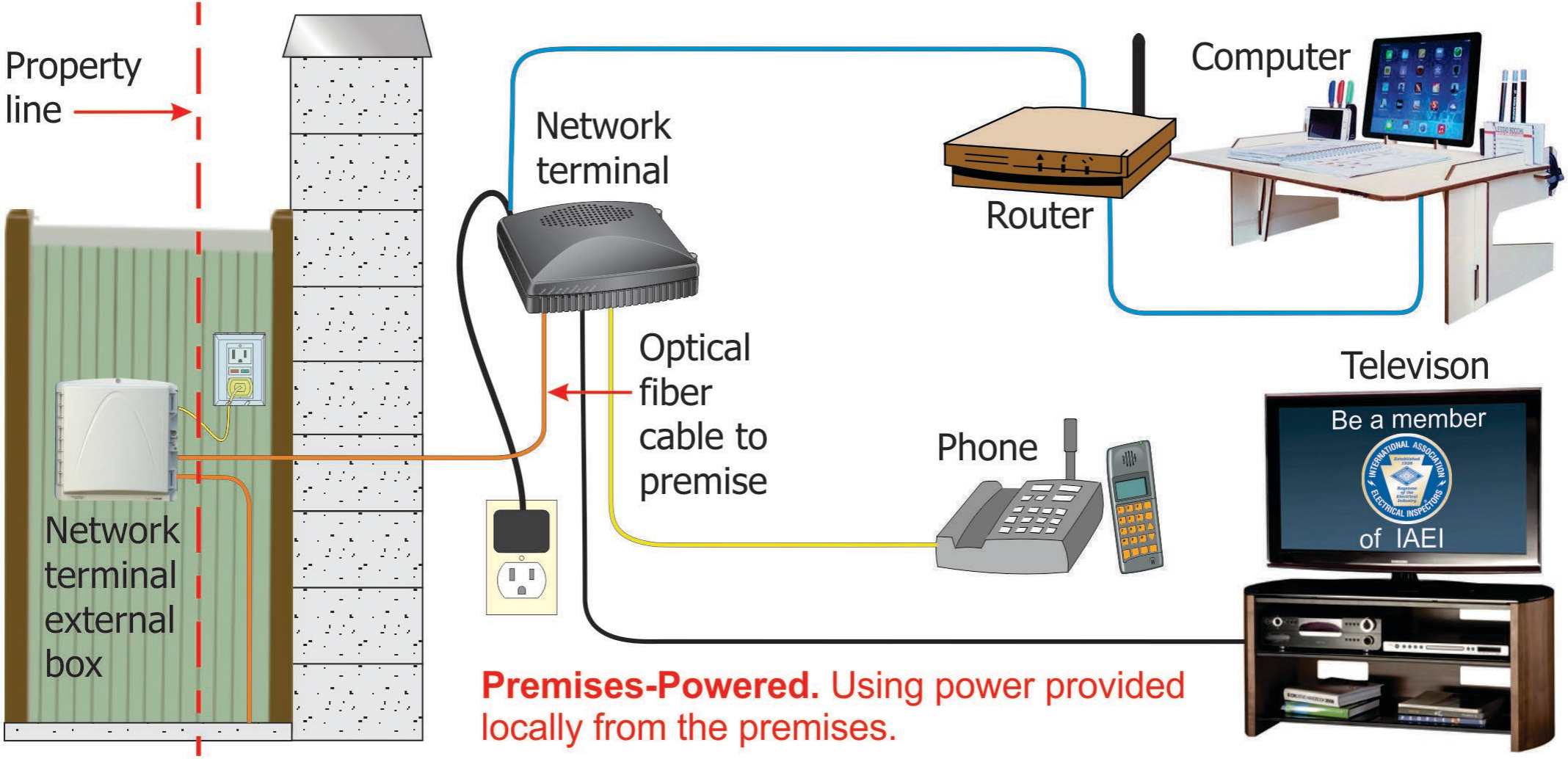
- Two new definitions were added to 840.2 to define the terms "**Broadband**" and "**Premises-Powered**"
- **Broadband.** Wide bandwidth data transmission that transports multiple signals, protocols, and traffic types over various media types.
- **Premises-Powered.** Using power provided locally from the premises.
- Previously, neither "**Broadband**" or "**Premises-Powered**" were defined in Article 840 *(Premises-powered Broadband Communications Systems)* or the *NEC*
- Definition for "**Broadband**" was added to provide an appropriate description of the circuits covered under Article 840
- Term "**Premises-Powered**" had to be defined as it now applies to more than one type of system

840.2 Definitions for Premises-Powered Broadband Communications Systems *(cont.)*

- Two new definitions were added to 840.2 to define the terms "**Broadband**" and "**Premises-Powered**" *(cont.)*
- Premises powered basically means that the power used by the communications system is **derived from the local premises power**, and this power source has **no limits on the power crossing a premises property line** or boundary
- **Example:** Network terminal being powered from a 125-volt, 15- or 20-ampere ac wall receptacle outlet or an uninterruptible power supply (UPS)/battery backup unit where the network terminal is a few feet from a structure
- This location is not necessarily "**on the premises**" based on prescribed property lines, legal boundaries, and/or utility definitions
- New definition of "**Premises-Powered**" would cover such an installation even though the network terminal might not be technically on the premise and keep this type of installation under the scope of Article 840

Article 840 Definitions: Premises-Powered Broadband Communications Systems

Broadband. Wide bandwidth data transmission that transports multiple signals, protocols, and traffic types over various media types.



Premises-Powered. Using power provided locally from the premises.

840.94 and 840.102 Premises Circuits Leaving the Building

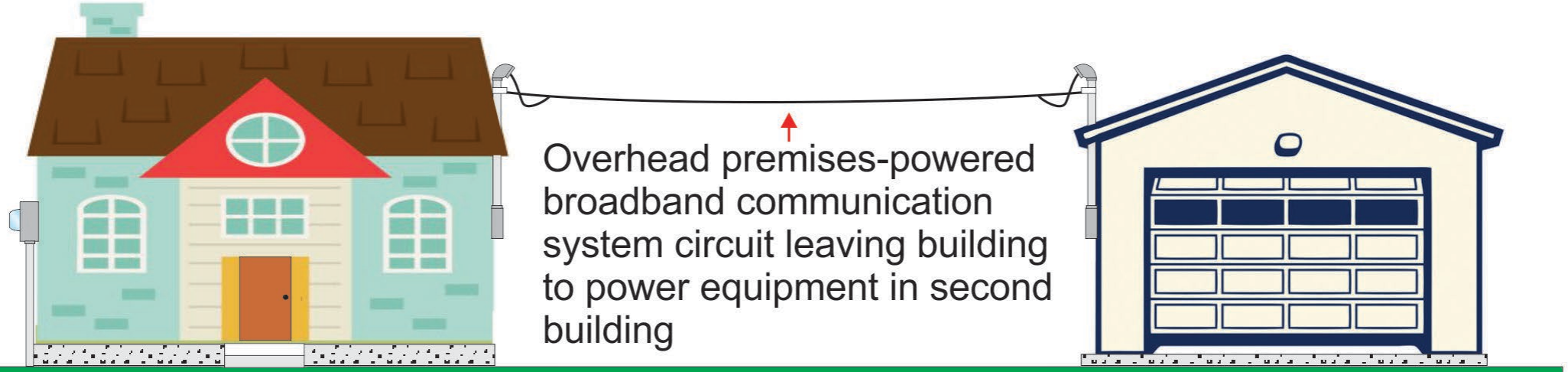
- Two new sections (840.94 and 840.102) added to provide requirements for **premises-powered broadband communication system (PPBCS) circuits** when they **leave the building** to power equipment **remote to that building**
- Previously, 840.101 contained provisions for PPBCS circuits where they **did not leave the building**, but no provisions existed for when PPBCS circuits **did leave the building**
- PPBCS circuits are being installed by utilities or service providers that provide power to exterior equipment such as an asymmetric digital subscriber line (ADSL), which is a type of digital subscriber line (DSL) technology
- The circuits are equipment on the network being powered from the premises which ultimately would power circuits going to **other premises**

840.94 and 840.102 Premises Circuits Leaving the Building *(cont.)*

- Two new sections (840.94 and 840.102) added to provide requirements for **premises-powered broadband communication system (PPBCS) circuits** when they **leave the building** to power equipment **remote to that building**
- These circuits are derived from the premises power to avoid having to run copper cable to the exterior location, avoid establishing a meter point, and/or avoid providing backup batteries *[sometimes referred to as "**reverse powering (RP)**"]*
- These added circuits are potentially exposed to lightning events and/or electric power ground faults
- They deserve and require the same protection and grounding and bonding means as other aerial, buried, or underground communications cables entering a building

840.94 and 840.102 Premises Circuits Leaving the Building

840.94: Requires circuits leaving a building to power equipment remote to that building or outside the exterior zone of protection defined by a 46 m (150 ft) radius rolling sphere, to comply with 805.90 *(Protective Devices)* and 805.93 *(Grounding, Bonding, or Interruption of Non-Current-Carrying Metallic Sheath Members of Communications Cables)*



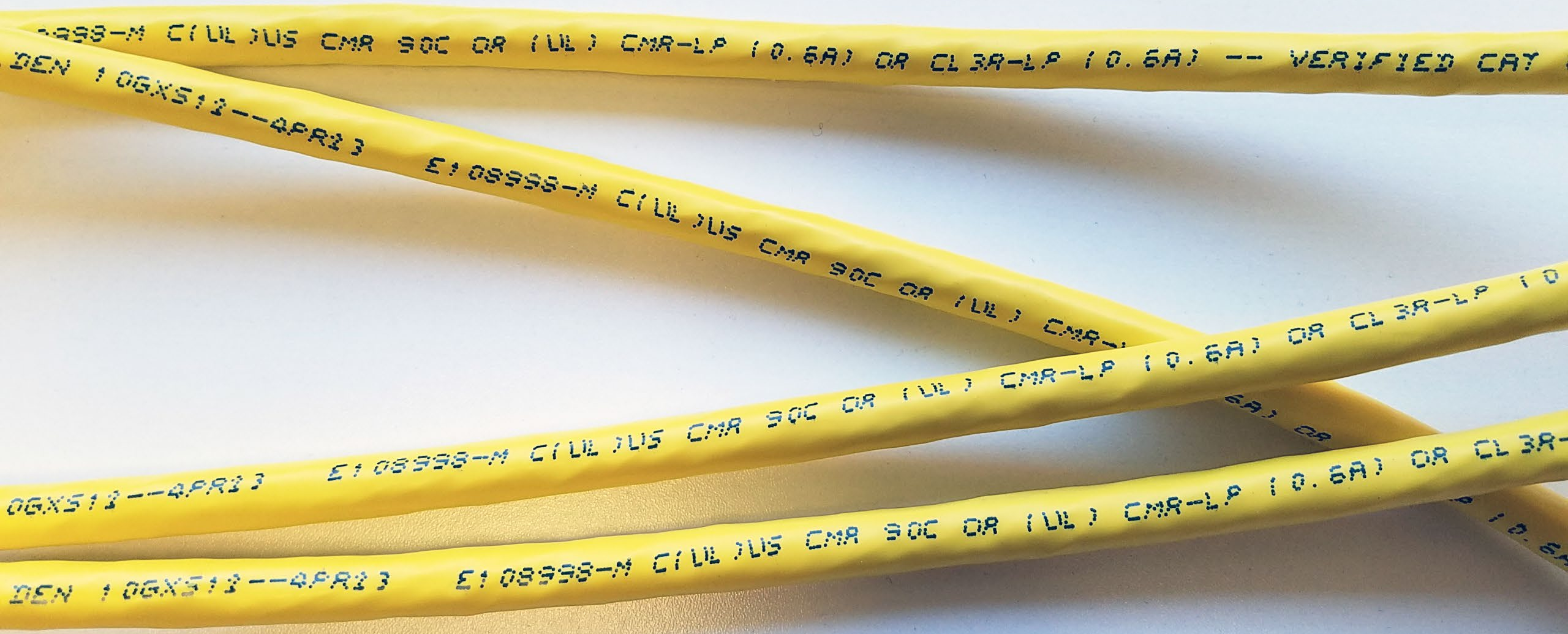
If coaxial cables are present, required to comply with 820.100 *(Cable Bonding and Grounding) (which references 800.100)* and 800.106

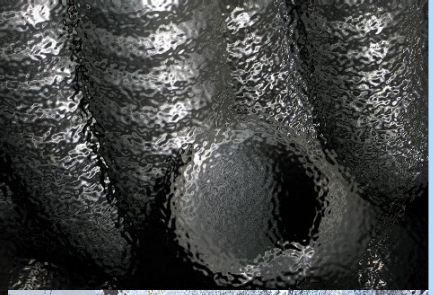
840.102: Requires communications wires and cables circuits leaving the building to power equipment remote to the building or outside the exterior zone of protection defined by a 46 m (150 ft) radius rolling sphere to comply with 800.100 *(Cable and Primary Protector Bonding and Grounding)* and 800.106 *(Primary Protector Grounding and Bonding at Mobile Homes)*

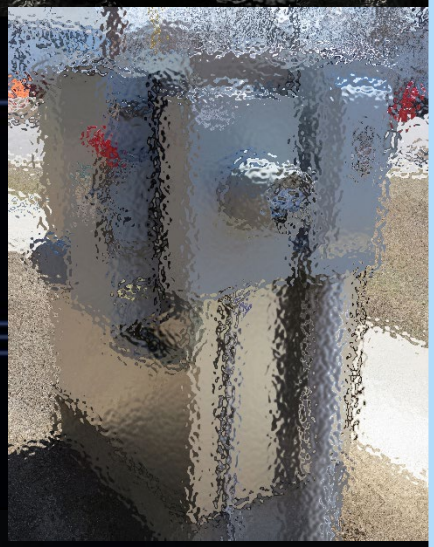
840.160 Powering Circuits (Premises-Powered Broadband Communication Systems)

- Revised text identifies **listing provisions** for communications cables, powered communications equipment, and the power source
- Communications cables that are listed in accordance with **805.179** are permitted to carry circuits for powering communications equipment *(in addition to carrying the communications circuit)*
- Communications equipment has to be listed in accordance with **805.170**
- Power source required to be listed in accordance with **840.170(G)**
- Installation of listed 4-pair communications cables for a communications circuit or installation where 4-pair communications cables are substituted for Class 2 and Class 3 cables in accordance with **725.154(A)** is required to comply with **725.144** with an exception *where the rated current of the power source does not exceed 0.3 amperes in any conductor 24 AWG or larger*

Communications cables listed in accordance with 805.179







Informative Annexes

Informative Annex A- Product Safety Standards

- Informative Annex A was reformatted to provide and add ***NEC* article numbers** and **appropriate product standards were added and updated**
- Previously, Informative Annex A had **two columns** of information; **(1)** the name of the product standard and **(2)** the product standard number
- Informative Annex A now has **three columns** of information; **(1)** the *NEC* article number where the referenced product standard can be found, **(2)** the product standard number, and **(3)** the name of the product standard
- **2017 *NEC*:** Informative Annex A referenced **236 product standards**
- **2020 *NEC*:** Informative Annex A references **352 product standards**
- Previous tabular format of Informative Annex A did not provide **correlation with various *Code* Articles** (*where can these product standard references be found throughout the NEC?)*

Informative Annex A - Product Safety Standards

Informative Annex A was reformatted to provide *NEC* article numbers and appropriate product standards were added

2017 *NEC* Informative Annex A *(in part)*

Product Standard Name	Product Standard Number
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
Automatic Electrical Controls	UL 60730-1

2020 *NEC* Informative Annex A *(in part)*

Article	Standard Number	Standard Title
110	UL 943	Ground-Fault Circuit-Interrupters
210	UL 1699	Arc-Fault Circuit-Interrupters
230	UL 1053	Ground-Fault Sensing and Relaying Equipment
240	UL 2735	Electric Utility Meters
	UL 198M	Mine-Duty Fuses
	UL 248-1	Low-Voltage Fuses — Part 1: General Requirements
	UL 248-2	Low-Voltage Fuses — Part 2: Class C Fuses
250	UL 467	Grounding and Bonding Equipment

Informative Annex C - Conduit, Tubing, and Cable Tray Fill Tables for Conductors and Fixture Wires of the Same Size

- Informative Annex C revised to include conductor fill tables for **cable trays** as well and for conduits and tubing
- Previous Informative Annex C contained **26 tables** for determining the maximum number of conductors or fixture wires permitted in various conduits and tubings
- New Informative Annex C is now contains **33 tables** for determining the maximum number of conductors or fixture wires permitted in various conduits, tubings **and cable trays**
- Rules and tables provided in Article 392 *(Cable Trays)* for determining the sizing of various cable tray types and sizes can be intimidating and complicated to some users of the *Code*
- **New tables** in Informative Annex C allows for **simplified determination** of the maximum number of cables or conductors allowed in a particular cable tray width and serve to **enhance safety** due to reductions of errors pertaining to incorrect cable selection and erroneous cable tray sizing calculations

Informative Annex C - Conduit, Tubing, and Cable Tray Fill Tables for Conductors and Fixture Wires of the Same Size

C.1 - Electrical Metallic Tubing (EMT)
C.1(A)* - Electrical Metallic Tubing (EMT)
C.2 - Electrical Nonmetallic Tubing (ENT)
C.2(A)* - Electrical Nonmetallic Tubing (ENT)
C.3 - Flexible Metal Conduit (FMC)
C.3(A)* - Flexible Metal Conduit (FMC)
C.4 - Intermediate Metal Conduit (IMC)
C.4(A)* - Intermediate Metal Conduit (IMC)
C.5 - Liquidtight Flexible Nonmetallic Conduit (Type LFNC-A)
C.5(A)* - Liquidtight Flexible Nonmetallic Conduit (Type LFNC-A)
C.6 - Liquidtight Flexible Nonmetallic Conduit (Type LFNC-B)
C.6(A)* - Liquidtight Flexible Nonmetallic Conduit (Type LFNC-B)
C.7 - Liquidtight Flexible Nonmetallic Conduit (Type LFNC-C)
C.7(A) - Liquidtight Flexible Nonmetallic Conduit (Type LFNC-C)
C.8 - Liquidtight Flexible Metal Conduit (LFMC)
C.8(A)* - Liquidtight Flexible Metal Conduit (LFMC)
C.9 - Rigid Metal Conduit (RMC)
C.9(A)* - Rigid Metal Conduit (RMC)
C.10 - Rigid PVC Conduit, Schedule 80
C.10(A)* - Rigid PVC Conduit, Schedule 80
C.11 - Rigid PVC Conduit, Schedule 40 and HDPE Conduit
C.11(A)* - Rigid PVC Conduit, Schedule 40 and HDPE Conduit
C.12 - Type A, Rigid PVC Conduit
C.12(A)* - Type A, Rigid PVC Conduit
C.13 - Type EB, PVC Conduit
C.13(A)* - Type EB, PVC Conduit
C.14- Type MC Cables Allowed in Cable Tray
C.15- Type MC Cables *(4C Multiconductor)*
C.16- Type TC Cables *(3C Multiconductor)*
C.17- Type TC Cables *(4C Multiconductor)*
C.18- Single Conductor Cables Allowed in Cable Tray
C.19- Single Conductor Cables Allowed in Cable Tray
C.20- Single Conductor Cables Allowed in Cable Tray


6 of 6
legrand
CABLOFIL
PW Cable Tray
Catalog Number: LD-6A2O-2024-24
Production Number:
Mark Number:
Purchase Order: 4300269400
MIN. X-SEC. Area: 1.5 SQ. IN.
Tray Type: VENTILATED
NEMA Load Class: 20C
Material Type: ALUMINIUM
CSA Load Class: E6M
MFG. Location: Pico Ladder
P033532
0690154683 / 000030
WARNING:
DO NOT USE AS A
WALKWAY, LADDER
OR SUPPORT FOR
PERSONNEL.
USE ONLY AS A
MECHANICAL SUPPORT
FOR CABLES, TUBING

Analysis of Changes – 2020 *NEC*

End of Part 2 – NEC Chapters 5 through 9

Training Presentation By:
International Association of Electrical Inspectors

How to Find 2020 National Electrical Code (NEC) Errata and Tentative Interim Amendments (TIA)

Users of the National Electrical Code (NEC) should be aware that the NEC may be amended from time to time through the issuance of Tentative Interim Amendments (TIA) or corrected by Errata. Errata is a list of errors in a printed work discovered after printing and shown with corrections.

The NEC at any point in time consists of the current edition together with any Tentative Interim Amendments and any Errata then in effect.

For official, detailed information visit the National Fire Protection Association's website:

https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70

Informative Annex C — Conduit, Tubing, and Cable Tray Fill Tables for Conductors and Fixture Wires of the Same Size

Raceway Fill Practice Calculations

Maximum Number of Conductors or Fixture Wires in Electrical Metallic Tubing (EMT)

What is the maximum number of #2/0 THW conductors in 4” EMT?

Maximum Number of Conductors or Fixture Wires in Electrical Metallic Tubing (EMT)

Solution:

- Step 1 – refer to Informative Annex Table C.1 – Maximum number of Fixture Wires or Conductors in Electrical Metallic Tubing (EMT) (Based on Chapter 9: Table 1, Table 4, and Table 5)

- Step 2 – locate 2/0 THW in the Conductor Size column of Table C.1

- Step 3 – follow the 2/0 THW row to the Trade Size 4 column

Answer = 17 - 2/0 THW conductors

Maximum Conductors or Fixture Wires in Electrical Nonmetallic Tubing (ENT)

What is the maximum number of #18 PFF fixture wires in ¾” ENT?

Maximum Conductors or Fixture Wires in Electrical Nonmetallic Tubing (ENT)

Solution:

- Step 1 – refer to Informative Annex Table C.2 – Maximum number of Fixture Wires or Conductors in Electrical Nonmetallic Tubing (ENT) (Based on Chapter 9: Table 1, Table 4, and Table 5)

- Step 2 – locate #18 PFF in the Conductor Size column of Table C.2

- Step 3 – follow the #18 PFF row to the Trade Size ¾ column

Answer = 35 - #18 PFF fixture wires

Maximum Conductors or Fixture Wires in Liquidtight Flexible Metal Conduit (LFMC)

What is the maximum number of #4/0 XHHW conductors in 3” LFMC?

Maximum Conductors or Fixture Wires in Liquidtight Flexible Metal Conduit (LFMC)

Solution:

- Step 1 – refer to Informative Annex Table C.8 – Maximum number of Fixture Wires or Conductors in Liquidtight Flexible Metal Conduit (LFMC) (Based on Chapter 9: Table 1, Table 4, and Table 5)

- Step 2 – locate #4/0 XHHW in the Conductor Size column of Table C.8

- Step 3 – follow the #4/0 XHHW row to the Trade Size 3 column

Answer = 9 - #4/0 XHHW conductors

Maximum Number of Conductors or Fixture Wires in Rigid Metal Conduit (RMC)

What is the maximum Number of #4 THHN conductors in 2” RMC?

Maximum Number of Conductors or Fixture Wires in Rigid Metal Conduit (RMC)

Solution:

- Step 1 – refer to Informative Annex Table C.9 – Maximum number of Fixture Wires or Conductors in Rigid Metal Conduit (RMC) (Based on Chapter 9: Table 1, Table 4, and Table 5)

- Step 2 – locate #4 THHN in the Conductor Size column of Table C.9

- Step 3 – follow the #4 THHN row to the Trade Size 2 column

Answer = - 16 #4 THHN conductors

Maximum Number of Conductors or Fixture Wires in Rigid PVC Conduit, Schedule 80

What is the maximum Number of #12 RHW conductors in 1½” Rigid PVC Conduit, Schedule 80?

Maximum Number of Conductors or Fixture Wires in Rigid PVC Conduit, Schedule 80

Solution:

- Step 1 – refer to Informative Annex Table C.10 – Maximum number of Fixture Wires or Conductors in Rigid PVC Conduit, Schedule 80 (Based on Chapter 9: Table 1, Table 4, and Table 5)

- Step 2 – locate #12 RHW in the Conductor Size column of Table C.10

- Step 3 – follow the #12 RHW row to the Trade Size 1½ column

Answer = 19 - #12 RHW conductors

Electrical License Types and Scope of Work

C-5 LIMITED ELECTRICAL CONTRACTOR

The holder of this license may perform only work limited to low voltage, alarm or signal work, audio and sound systems, and telephone-interconnect. The voltage of any system is not to exceed forty-eight (48) volts or eight (8) amperes where such work commences at an outlet receptacle or connection previously installed by a person holding the proper electrical license. The requirements to qualify for this license examination shall be two (2) years as a properly licensed journeyperson or at least six (6) years of equivalent experience and training.

C-6 LIMITED ELECTRICAL JOURNEYPERSON

The holder of this license may perform only work as defined for C-5 category and only while in the employ of a licensed electrical contractor. The requirements to qualify for this license exam shall be the completion of a registered apprenticeship program or at least four (4) years of equivalent experience and training.

C-7 LIMITED ELECTRICAL SIGN CONTRACTOR

The holder of this license may perform only work limited to installing, servicing, maintaining and testing electric signs where such work commences at a dedicated outlet receptacle or connection directly adjacent to such sign. The requirements to qualify for this license examination shall be two (2) years as a properly licensed journeyperson or equivalent experience and training.

C-8 LIMITED ELECTRICAL SIGN JOURNEYPERSON

The holder of this license may perform only work limited to installing, servicing, maintaining and testing electric signs where such work commences at a dedicated outlet receptacle or connection directly adjacent to such sign and only while in the employ of a contractor licensed for such work. The requirements to qualify for this license examination shall be the completion of a registered apprenticeship program or equivalent experience and training.

E-1 UNLIMITED ELECTRICAL CONTRACTOR

The holder of this license shall be permitted to do all electrical work as defined in section 20-330 of the general statutes. The requirements to qualify for this license

exam shall be two (2) years as a unlimited licensed journeyperson or at least six (6) years of equivalent experience and training.

E-2 UNLIMITED ELECTRICAL JOURNEYPERSON

The holder of this license shall be permitted to do all electrical work as defined in section 20-330 of the Connecticut General Statutes, and only while in the employment of a properly licensed contractor. The requirement to qualify for this license exam shall be the completion of a registered apprenticeship program or at least four (4) years of equivalent experience and training.

L-1 ELECTRICAL LINES CONTRACTOR

The holder of this license may perform only work limited to line construction, including distribution systems, and their allied work, for public and private companies; installation, maintenance and repair of all high-voltage cable splicing and pulling wire for all systems in excess of 2,400 volts; traffic signal and highway lighting installation, maintenance and repair. The requirements to qualify for this license examination shall be two (2) years as a properly licensed journeyperson or at least six (6) years of equivalent experience and training.

L-2 ELECTRICAL LINES JOURNEYPERSON

The holder of this license may perform only work limited to line construction, including distribution systems, and their allied work, for public and private companies; installation, maintenance and repair of all high-voltage cable splicing and pulling wire for all systems in excess of 2,400 volts; traffic signal and highway lighting installation, maintenance and repair, and only while in the employ of a contractor licensed for such work. The requirements to qualify for this license examination shall be the completion of a registered apprenticeship program or at least four (4) years of equivalent experience and training.

L-5 LIMITED ELECTRICAL CONTRACTOR

The holder of this license may perform only work limited to low voltage, alarm or signal work, audio and sound systems. The installation or repair of any telecommunication work is not authorized with the exception of the interface wiring from an alarm system to an existing telephone connection for monitoring purposes. The voltage of the system is not to exceed 25 volts or five amperes where such work commences at an outlet receptacle or connection previously installed by

a person holding the proper electrical license. The requirements to qualify for this license examination shall be two (2) years as a properly licensed journeyperson or at least six (6) years of equivalent experience and training.

L-6 LIMITED ELECTRICAL JOURNEYPERSON

The holder of this license may perform only work limited to low voltage, alarm or signal work, audio and sound systems, and only while in the employ of a contractor licensed for such work. The installation or repair of any telecommunication work is not authorized with the exception of the interface wiring from an alarm system to an existing telephone connection for monitoring purposes. The voltage of the system is not to exceed 25 volts or five amperes where such work commences at an outlet receptacle or connection previously installed by a person holding the proper electrical license. The requirements to qualify for this license examination shall be the completion of a registered apprenticeship program or at least four (4) years of equivalent experience and training.

T-1 LIMITED ELECTRICAL CONTRACTOR

The holder of this license may perform only work limited to telephone-interconnect systems where such work commences at an outlet receptacle or connection previously installed by a person holding the proper electrical license. The requirements to qualify for this license examination shall be licensed journeyperson or at least six (6) years of equivalent experience and training.

T-2 LIMITED ELECTRICAL JOURNEYPERSON

The holder of this license may perform only work as defined for the T-1 category and only while in the employ of a licensed electrical contractor. The requirements to qualify for this license examination shall be the completion of a registered apprenticeship program or at least four (4) years of equivalent experience and training or five (5) years as a registered public service technician.

PV-1 LIMITED SOLAR ELECTRIC CONTRACTOR

The holder of this license may perform only work limited to Solar Electric systems; which means the installation, erection, repair, replacement, alteration or maintenance of photovoltaic or wind
generation systems, including storage and distribution of such energy
for heat, light, power or other purposes to a point immediately inside a structure or

adjacent to an end use. The requirements to qualify for this license examination shall be two years as a solar journeyperson or equivalent experience and training.

PV-2 LIMITED SOLAR ELECTRIC JOURNEYPERSON

The holder of this license may perform only work limited to Solar Electric systems; which means the installation, erection, repair, replacement, alteration or maintenance of photovoltaic or wind generation systems, including storage and distribution of such energy for heat, light, power or other purposes to a point immediately inside a structure or adjacent to an end use and only while in the employ of a licensed electrical contractor. The requirements to qualify for this license examination shall be the completion of a registered apprenticeship program or equivalent experience and training.

* **Clarification:** The Electrical Work Examining Board has clarified "to a point inside a structure or adjacent to an end use" by unanimous vote, that a **PV-1 or PV-2 license holder is not permitted to connect to any existing panel, junction box, wiring or circuit(s) on the premises**. They are limited to properly terminating their wiring into a junction box or controller of theirs that is not in any way connected to the buildings existing electrical system or utility meter. Connection to the buildings existing electrical system or utility meter can only be performed by a licensed E-1 or E-2 license holder.

Fire Protection and Safety Engineering Technology: A Promising Field

Fires can be catastrophic disasters. Flames and smoke can damage residences, commercial buildings, and critical infrastructure. People can sustain severe injuries in fires, resulting in devastating fatalities.

As a result, many governments require businesses and builders to abide by certain codes, implement safety equipment, and create fire safety plans to protect occupants in case of disaster.

Fire protection and safety engineering technology is critical to minimizing loss during these events. This field focuses on applying science to save lives, protect structures, and minimize damage during a fire.

An Overview of Fire Protection and Safety Engineering Technology

Fire protection engineering extends far beyond a fire alarm or sprinkler system. Exciting advancements are expanding the possibilities of fire protection technology, such as 5G connectivity and Internet of Things (IoT) technologies.

Elements of Fire Protection and Safety Engineering

Individuals within the fire protection and safety engineering field focus on applying science and technology to protect humans, property, and the environment from destruction during a fire. It encompasses technologies to fight, detect, prevent, and protect against this type of devastation.

There are many branches within the fire protection field. For example, some professionals build fire suppression systems, which include technologies like sprinkler systems and fire extinguishers. Others build passive fire protection, such as smoke barriers and space separation.

Fire protection engineers may also engage in the following activities:

- Managing wildfires
- Administering fire prevention programs
- Devising smoke control and management techniques
- Using fire modeling and dynamics to predict fire behavior
- Analyzing and planning for human behavior during disaster events
- Planning and assessing building designs, layouts, and spaces for fire compliance

- Designing and architecting escape routes, such as emergency exits
- Analyzing risk factors, like economic impact and infrastructure vulnerabilities

Recent Developments and Trends in Fire Protection Technology

As time goes on, fire protection technologies are becoming more advanced and sophisticated. Rather than focusing on defending against fires, engineers are looking at ways to detect fires as early as possible to minimize potential damage. Sensing technologies, visualization software, and predictive analytics are integral to these emerging trends.

There are several exciting developments in fire protection technology. Some of the most promising include IoT or sensing technologies, 5G connectivity, and building information modeling (BIM).

- **Internet of Things Capabilities:** IoT devices have sensors that measure changes in the surrounding environment. Sensing technology can detect the early development of fires, helping to prevent and minimize human and property loss. For example, IoT devices can measure changes in temperature or use visual sensing to identify the start of a fire. Smoke or heat detection are usually late-stage indicators of a fire, but camera-based or mobile phone visualization IoT devices can support earlier detection. These technologies rely on images rather than rising smoke or growing flames. As a result, first responders can receive alerts before a fire grows out of control and requires extensive resources to fight.

- **5G Technology:** One of the most important factors during a disaster event is connectivity, but fire often destroys communication infrastructure. Without access to the internet, first responders face challenges providing critical services and people cannot alert others for help. 5G technology, which is the next generation of wireless connectivity, provides high wireless speeds at low latency. Implementing small cell networks in an area that is recovering from a fire can provide this necessary connectivity, even in remote areas during wildfires. This fast network also enables advanced communications and capabilities, including IoT sensing. As a result, 5G drives the modernization and availability of fire safety technologies around the world.

- **Anomaly Detection Systems:** Power supply systems are critical pieces of infrastructure that need extra protection in the event of a fire. When an electrical system encounters a fire, it will undergo significant stress. Implementing anomaly detection systems can help stakeholders identify developing stress and pinpoint a potential disaster. These systems can be especially helpful for larger operations where fire protection is critical, like factories or airports.

- **Building Information Modeling:** BIM is a process that uses software to render a digital representation of a building. It helps engineers, architects, and other stakeholders better understand the physical and functional characteristics of the facilities that they build. For fire protection, BIM can help engineers model fire alarm and sprinkler systems, identify potential safety hazards, and implement passive protection measures, like dampers and penetration sealants. Engineers can also use BIM to develop virtual reality simulations for first responders, improving fire safety and rescue efficiency for various situations.

BIM or IoT technologies can make it easier for entities to protect against fires. 5G connectivity can make it simpler for emergency workers to communicate with one another and provide services. If these technologies integrate with one another, fire protection engineers can build powerful detection and prevention tools, minimizing loss during a fire.

The Purpose of Fire Protection and Safety Engineering Technology

Fires pose a major risk to residential and commercial buildings alike. More and more industries, government agencies, and research institutions are investing in this field to minimize human loss, comply with regulations, and protect critical structures.

There are several important purposes to fire protection engineering, including operational stability, environmental protection, and the protection of human lives.

Protecting Human Lives

The primary goal of fire protection and engineering technology is to prevent the loss of life. Fire safety systems must protect occupants of a building against flames and smoke and provide a safe exit route in the event of an emergency. Early detection systems, such as smoke or heat detection, are critical for this purpose.

Additionally, fire protection engineers help ensure that all structures comply with safety best practices and fire code requirements. They advise contractors and businesses on potential hazards, helping to prevent large-scale disasters due to infrastructure noncompliance.

Defending Structures

A major component of fire protection involves defending and protecting property. Engineers can implement active detection systems that help fight against flames and smoke, like sprinkler systems and fire extinguishers.

When planning a building, they may use smoke barriers and other passive measures to limit the potential impact of a fire. Engineers may also help identify weaknesses in critical infrastructure and deploy solutions to maintain connectivity during a disaster.

Minimizing Environmental Damage

Fires can wreak havoc on the environment, especially if the disaster involves hazardous materials or protected wildlife and natural areas. For example, a fire at an industrial plant could cause runoff to enter the water supply. Endangered animals could be at risk during a wildfire.

Fire protection engineers assess the risk of environmental damage and devise solutions to limit the potential impact. With careful research and planning, engineers can help commercial and government entities minimize environmental damage.

Ensuring Operational Stability

When disaster strikes, critical services like medical care, police, and fire protection need to be able to continue. Fire protection technologies help limit the damage that businesses and critical infrastructure sustain.

Engineers go beyond standard compliance rules to prevent disruption to major operations, from ensuring that buildings are structurally stable to providing options for connectivity.

Planning Emergency Response and Mitigation Measures

Proper planning is critical in emergency response, prevention, and mitigation. Fire protection engineers help plan for emergency events by analyzing both human and fire behavior. All of these efforts protect against the loss of life and property.

These professionals use predictive analysis to determine fire progression and dynamics, helping identify at-risk structures and individuals. They use examples of human behavior in the past to plan rescue and evacuation efforts.

Businesses and governments can then use the results of these evaluations to devise comprehensive emergency response and mitigation plans.

Fire Protection and Safety Engineering Technology Disciplines

Fire protection technology is an interdisciplinary field that involves multiple areas of expertise and study. As a result, there are many skills and qualifications that a student will need to obtain in order to pursue this career path.

Degree and certification programs in fire protection and safety engineering require students to take courses in mathematics, physics, and communication. Required classes may revolve around thermodynamics, statistics, and engineering design and modeling.

In addition to general education, students will also need to complete classes that focus on fire safety and engineering. These courses may focus on the following subjects:

- Fire dynamics
- Fire prevention
- Industrial fire safety
- Fire safety hazard recognition
- Human psychology during fires
- Industrial hygiene best practices
- Hazardous materials management
- Fire suppression and detection systems
- Fire protection structure and system design
- Emergency response, preparation, and mitigation
- Emergency services administration

Students who graduate from fire protection and safety engineering technology programs go on to pursue a wide range of careers. In addition to fire protection engineering, alumni can become fire inspectors, research fire science and fire dynamics, or join a firefighting force.

Fire Protection Engineer Educational Requirements

Fire protection engineering is an exciting career path with many opportunities available across disciplines. However, individuals will need to obtain the right education, experience, and certification in order to obtain a job within this field.

How to Become a Fire Protection Engineer

A fire protection engineer builds technologies to prevent, detect, and defend against fires. These professionals also advise contractors, businesses, governments, and other entities on fire safety and planning.

A student typically needs to complete a formal course of education in order to pursue this career path. In some cases, a student will also need to take a licensing exam. These requirements vary from country to country.

In the United States, for example, most jobs require potential hires to obtain a bachelor's degree in engineering. Students can participate in general engineering programs and take fire-related courses or pursue a fire protection engineering major.

After completing their education, prospective engineers will need to take the Fundamentals of Engineering (FE) test from the National Council of Examiners for Engineering and Surveying (NCEES). If they pass the FE exam, students can apply for jobs in the fire protection engineering discipline.

Once an individual has at least four years of experience in their role, they can take the Principles and Practice of Engineering (PE) exam in fire protection from NCEES. Following the PE exam, engineers can pursue specialist certifications and graduate programs in fire protection.

What to Look for in a Fire Protection Engineering Program

If you are looking for a fire protection and safety engineering technology program, it is important to assess your desires and priorities. When assessing various programs, use the following questions to weigh each option and find the right program for you:

- Does the program focus completely on fire protection, or is it a general engineering course?
- If the program focuses on general engineering, does the institution have courses or tracks for fire protection and engineering?
- Does the institution have the appropriate accreditation from educational and professional organizations?
- Are there internships, volunteer programs, or hands-on learning opportunities available in the fire protection space?
- Does the institution provide support for certification, licensing, and career development?
- Are there alumni who you can connect with to learn more about the program and potential career opportunities?
- Are you able to participate in electives and expand your engineering knowledge? Examples include courses on the fundamentals of speech recognition or machine learning basics.

Future Advances in Fire Protection Technology

Fire protection technology is critical to preventing the loss of human lives, property, and critical infrastructure. Future advances in connectivity, including 5G capabilities and sensing technologies, will further enhance this field and minimize the impact of fire disasters.

Want to learn more about recent advancements in fire protection and safety engineering technology? Browse IEEE's library of papers from the 2019 9th International Conference on Fire Science and Fire Protection Engineering.

Interested in becoming an IEEE Public Safety Technology Initiative member? Joining this community of industry experts and professionals will give you access to the resources and opportunities you need to keep on top of changes in technology, as well as help you get involved in standards development, network with other professionals in your local area or within a specific technical interest, mentor the next generation of engineers and technologists, and so much more. Interested in joining an initiative commitee? Complete the Committee Interest Form to tell us your area of interest and join today!

- Sitemap
- Contact IEEE Public Safety
- Accessibility
- Nondiscrimination Policy
- IEEE Ethics Reporting
- IEEE Privacy Policy
- Terms

IEEE Public Safety Technology Initiative

The future of fire safety: Advancements in fire alarm technology

November 14, 2023
6 min read | Adam Klein

-
-
-
-

Listen to article

This audio was created using Microsoft Azure Speech Services

Ever pondered how technology is reshaping our perspective on fire safety? Well, consider yourself fortunate because today, we're delving into the future of fire safety and the remarkable advancements in fire alarm systems that are revolutionising building safety like never before.

The future of fire safety is looking brighter with the advancements in fire alarm technology. With new innovations in sensors, wireless systems, and artificial intelligence, fire alarms can now detect fires more accurately and quickly. This has the potential to save lives and minimize damage in the event of a fire.

Moreover, a rising trend is observed in the realm of fire alarm system integrations, enabling seamless communication with other safety systems within a building, including fire suppression, emergency lighting, and access control.

Fireman and burning factory.

What is a Fire Alarm System?

A fire alarm system is a network of devices designed to detect and warn people about the presence of fire or smoke in a building or other enclosed spaces. In the past, fire alarm systems primarily relied on basic detectors, such as smoke detectors and heat sensors, to alert occupants of a fire. While these systems have been effective to a certain extent, they have limitations. They were prone to false alarms, and their detection capabilities were not always efficient.

However, thanks to rapid advancements in technology, fire alarm systems have undergone a dramatic transformation. New innovations, such as wireless systems and artificial intelligence, have revolutionized the way fire alarms operate. These advancements have the potential to save lives and minimize damage in the event of a fire.

What Are the Types of Fire Alarm Systems?

Fire alarm systems come in various types, each offering unique features and benefits:

- Conventional Fire Alarm Systems

These systems divide the building into zones, with each zone having a separate circuit connected to a control panel. When a detector is triggered in a zone, the control panel can identify the general area and activate the corresponding alarm. Conventional systems are widely used and offer a cost-effective solution for many buildings.

- Addressable Fire Alarm Systems

Addressable systems provide a more precise approach to fire detection. Each device within the system has a unique address, allowing the control panel to pinpoint the exact location of a fire. This feature enables swift and targeted response from emergency services and enhances the overall effectiveness of the system.

- Wireless Fire Alarm Systems

Wireless fire alarm systems are becoming increasingly popular due to their ease of installation and flexibility. These systems use wireless sensors and communication to connect to a central control panel, eliminating the need for complex wiring. Wireless fire alarm systems are ideal for retrofitting buildings or areas where wiring is difficult or impossible.

- Hybrid Fire Alarm Systems

Hybrid systems combine the best features of conventional and addressable systems. They offer flexibility in installation and cost-effectiveness, making them suitable for a wide range of building types and sizes.

- Voice Evacuation Systems

Voice evacuation systems provide clear and concise instructions to occupants during emergencies. By using pre-recorded or live voice messages, these systems guide individuals to safety in a calm and organised manner. Voice evacuation systems are particularly valuable in large buildings or noisy environments where audible alarms alone may not be sufficient.

- Aspirating Smoke Detection Systems

In areas with high ceilings or where traditional detectors may not be practical, aspirating smoke detection systems offer an innovative solution. These systems use a network of pipes and a central detection unit to detect smoke particles in the air. By providing early detection, they help minimize response time and enhance overall fire safety.

Each type of fire alarm system has its own advantages and limitations. The choice of system depends on factors such as the building's size, layout, occupancy type, and the level of protection required.

Latest Advancements in Fire Alarm Technology

Now, let's dive into the latest advancements in fire alarm technology that are shaping the future of fire safety.

- Integration with Building Management Systems

The integration of fire alarm systems with building management systems (BMS) is a significant advancement in enhancing overall building safety and emergency response. By integrating fire alarm systems with the BMS, building operators gain centralized control and monitoring capabilities. This integration allows for automated responses, such as closing fire-rated doors, initiating HVAC shutdown, and activating emergency lighting. The integration also improves overall life safety and reduces response times. The detailed information of occupancy, door access, and alarm location can expedite the generation of muster reports and

bring awareness to key individuals. Moreover, sustainability outcomes can be achieved with digitzsation of both fire and access control data.

- Advanced detection technology

The latest advancements in fire alarm technology have brought us advanced detection capabilities that go beyond traditional methods. Video smoke detection utilises cameras to detect the visual signature of smoke, enabling early and accurate detection. Multi-criteria detectors combine smoke, heat, and carbon monoxide sensors to improve overall detection accuracy and reduce false alarms.

- Remote monitoring and control

Remote monitoring and control capabilities have transformed the way fire alarm systems are managed. With remote access to fire alarm systems from a central location, monitoring and managing these systems has never been easier. This is particularly beneficial for large or complex buildings that have multiple fire alarm systems spread across different locations.

- Cloud-based fire alarm systems

Cloud technology has revolutionized the way fire alarm systems operate. Cloud-based fire alarm systems store data in the cloud, eliminating the need for physical servers. This enables real-time monitoring and analysis of fire alarm data from anywhere in the world. By harnessing the power of the cloud, building owners and fire safety professionals can access crucial information instantly, allowing for swift decision-making and response.

- Internet of Things (IoT) fire alarm systems

IoT fire alarm systems have emerged as a game-changer in the realm of fire safety. By utilising sensors, communication technology, and cloud-based computing, these systems provide real-time monitoring and analysis of fire alarm data.

Leveraging Advanced Technology for Fire Safety

In the quest for a more sustainable future, Schneider Electric is at the forefront of leveraging advanced technology to promote fire safety. Schneider Electric has established Green Yodha, a sustainability initiative aimed at minimizing environmental footprints and championing sustainable practices. Our team of sustainability experts brings extensive knowledge and experience in global carbon reduction programs, energy efficiency measures, and renewable

energy sources. By empowering clients to achieve net-zero status, Schneider Electric is paving the way for a greener and more sustainable world. Moreover, Schneider Electric's EcoStruxure™ Building Operation (EBO), a smart building management solution ensures safety of occupants in an emergency. EBO establishes a secure connection between hardware, software, and services using an Ethernet IP backbone. This integration enables you to enhance building efficiency, optimize comfort and productivity, and elevate the overall value of your building.

As technology continues to evolve, the future of fire safety looks brighter than ever before. Advancements in fire alarm technology, such as wireless systems, voice evacuation, and advanced detection capabilities, are revolutionising the way we approach fire safety in buildings. By embracing these cutting-edge technologies and promoting their widespread adoption, we can create safer environments, protect lives, and minimise damage in the face of fire emergencies. The future is here, and it's time to harness the power of innovation to safeguard our communities.

Tags: alarms, EcoStruxure Building Operation, fire prevention, fire safety

Telecommunication Grounding & Bonding

Anthony I Madroño

RCDD DCDC HP-AIS CAP-RS REE MBA

Managing Director – ISI Corp

Member - IEEE

Lifetime Member – IIEE

Philippines BICSI Chair

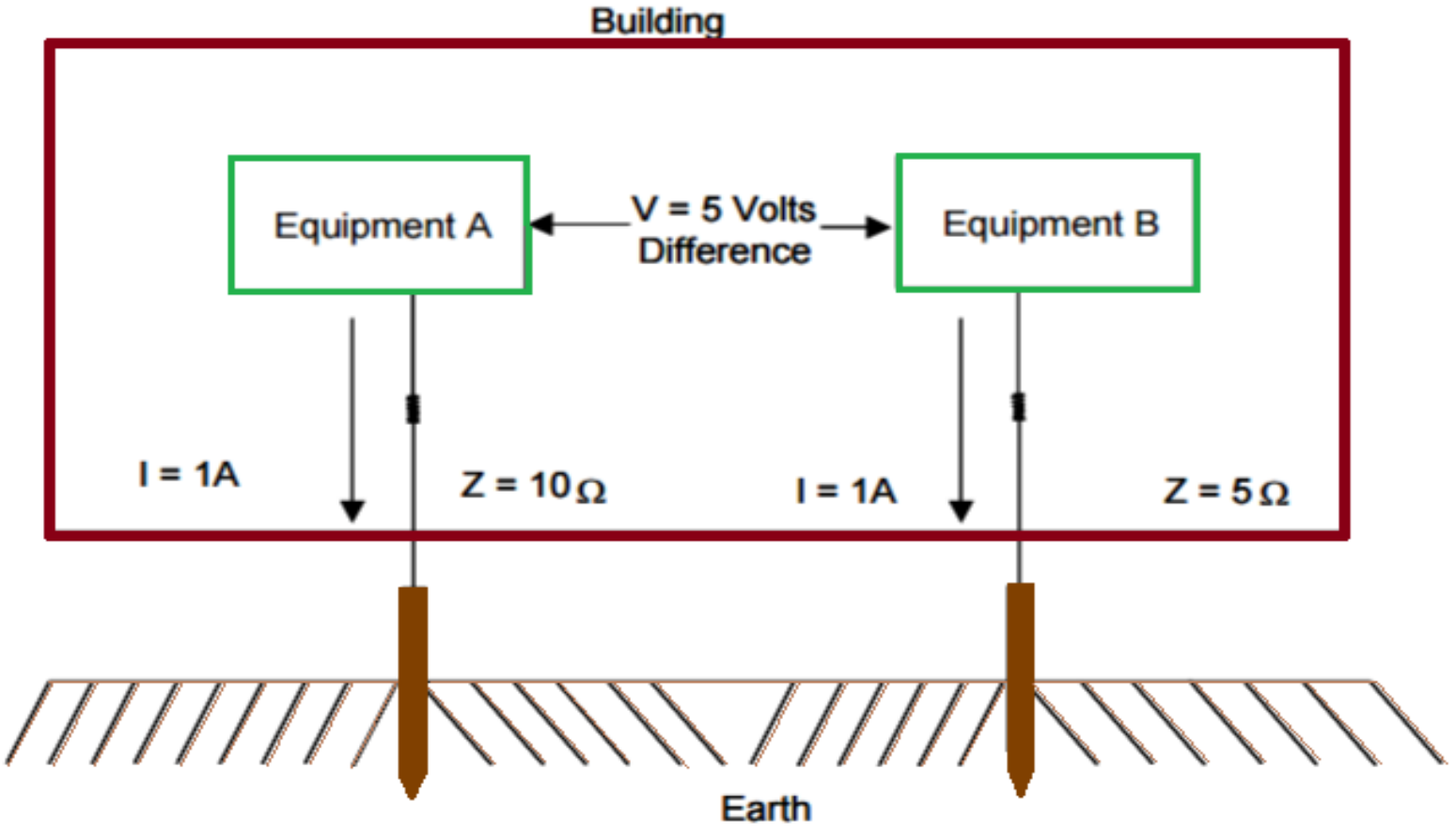
Codes and Standard References

- ANSI J-STD 607B
- ANSI/NECA/BICSI 607:2011
- ANSI/TIA 607B: 2011
- BICSI TDMM 13th Edition:2014
- BS 7430:2011
- IEEE 1100:2005
- IEEE 81:2012
- ISO/IEC 30129:10.2015
- NFPA 70:2014 (NEC)
- Motorola R56:2005

Why the need for Grounding and Bonding

- Equipment Protection
- Satisfy Warranty Requirement
- System Performance
- Service Protection
- Personnel Safety
  (code requirement – NEC/CSA/BS/IEC)

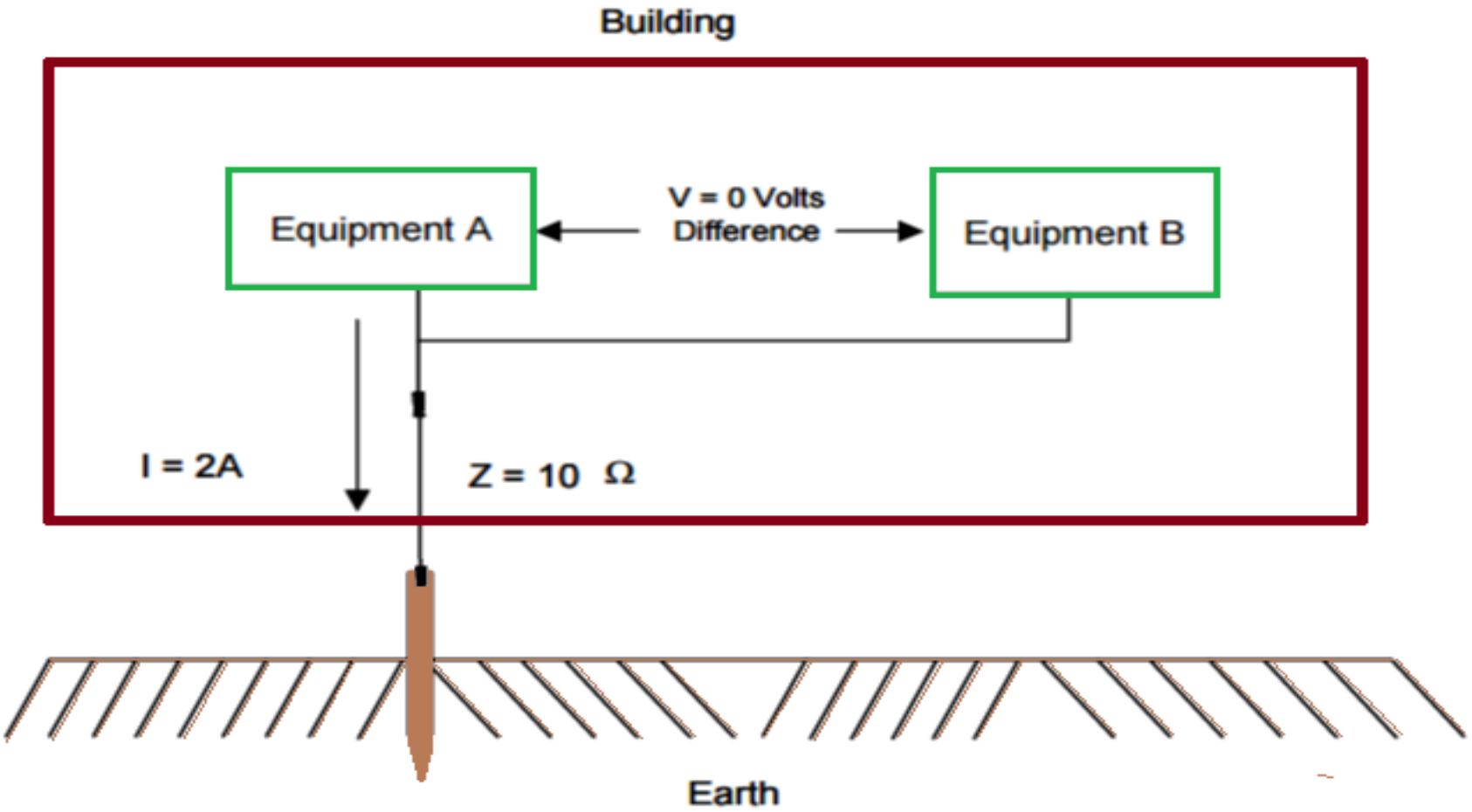
Case: Two Ground Reference Points



Effect of Two Earth Reference Points

(voltage difference between two equipment)

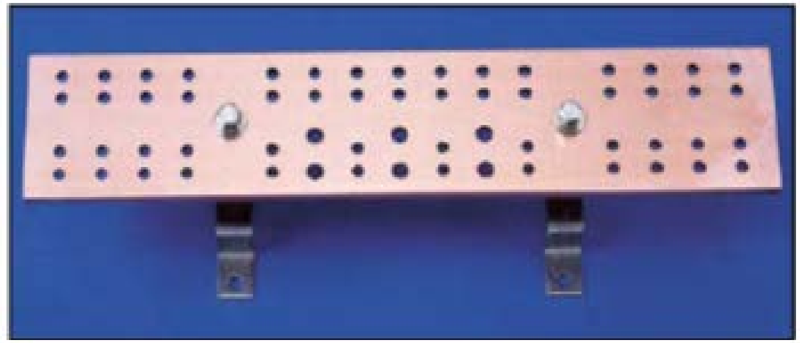
Case: Single Equipotential Plane



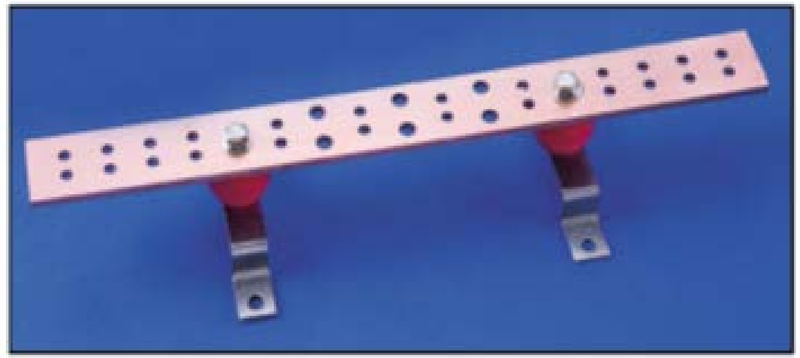
Effect of Single-point Reference of all Equipment (0 volts Difference)

1. Grounding & Bonding Components

Main Telecommunication Grounding Busbar (TMGBB)

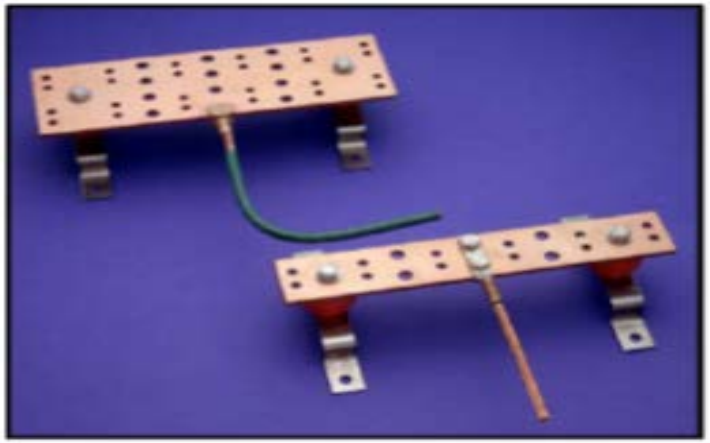


Telecommunication Grounding Busbar (TGBB)

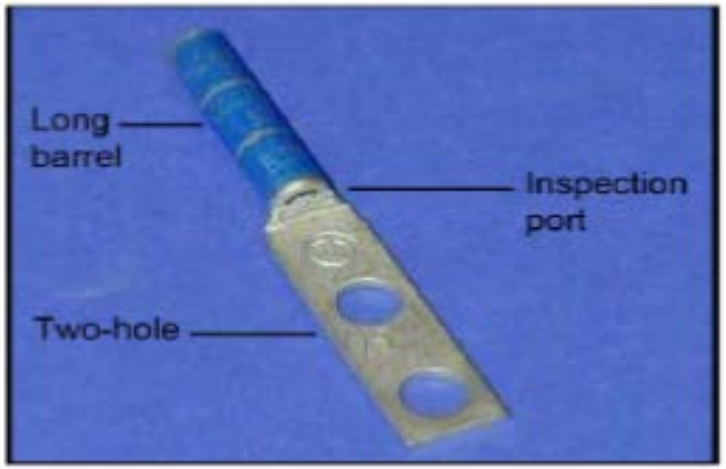


2-Hole Long Barrel Terminal Lugs & Compression Type Connectors

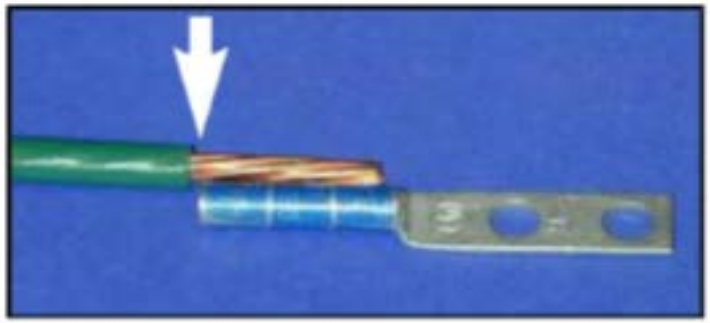
1. Grounding & Bonding Components



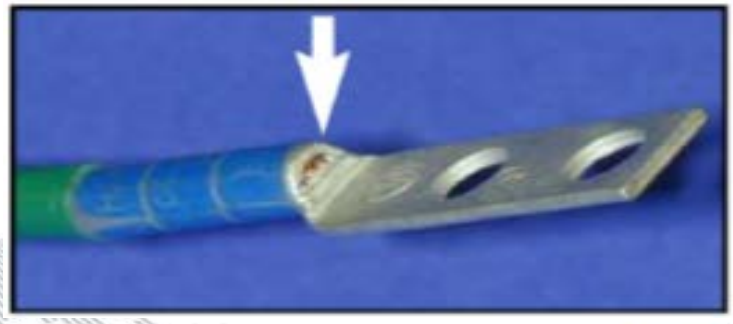
Exothermic connection & a 2-hole lug connection to a busbar



2-Hole Terminal Lug



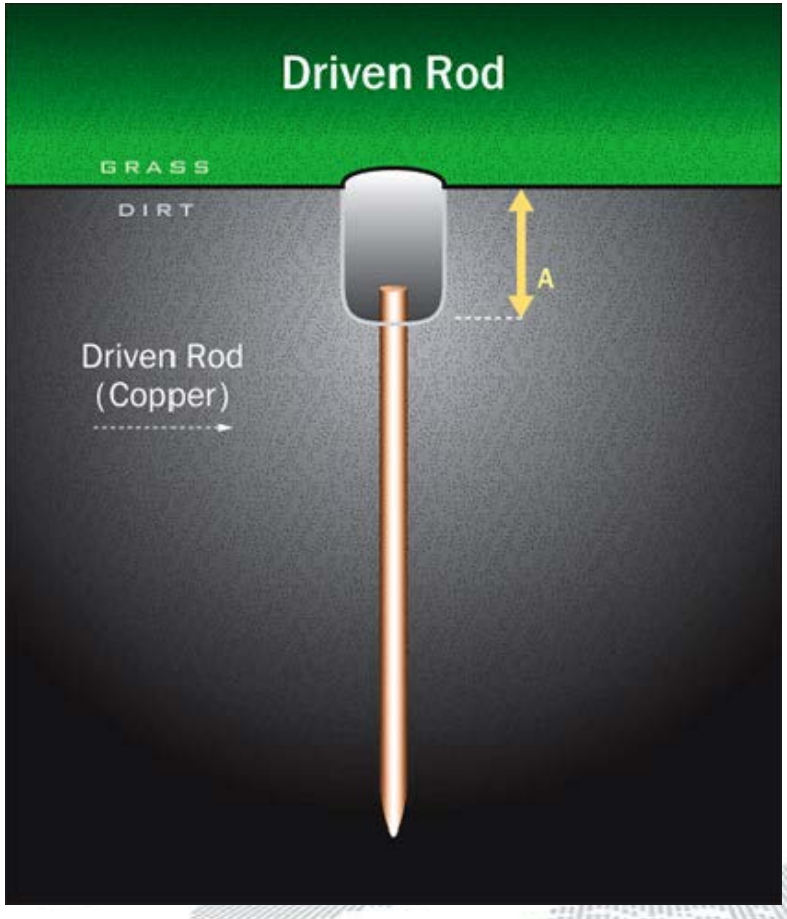
Trimmed Insulation from a conductor



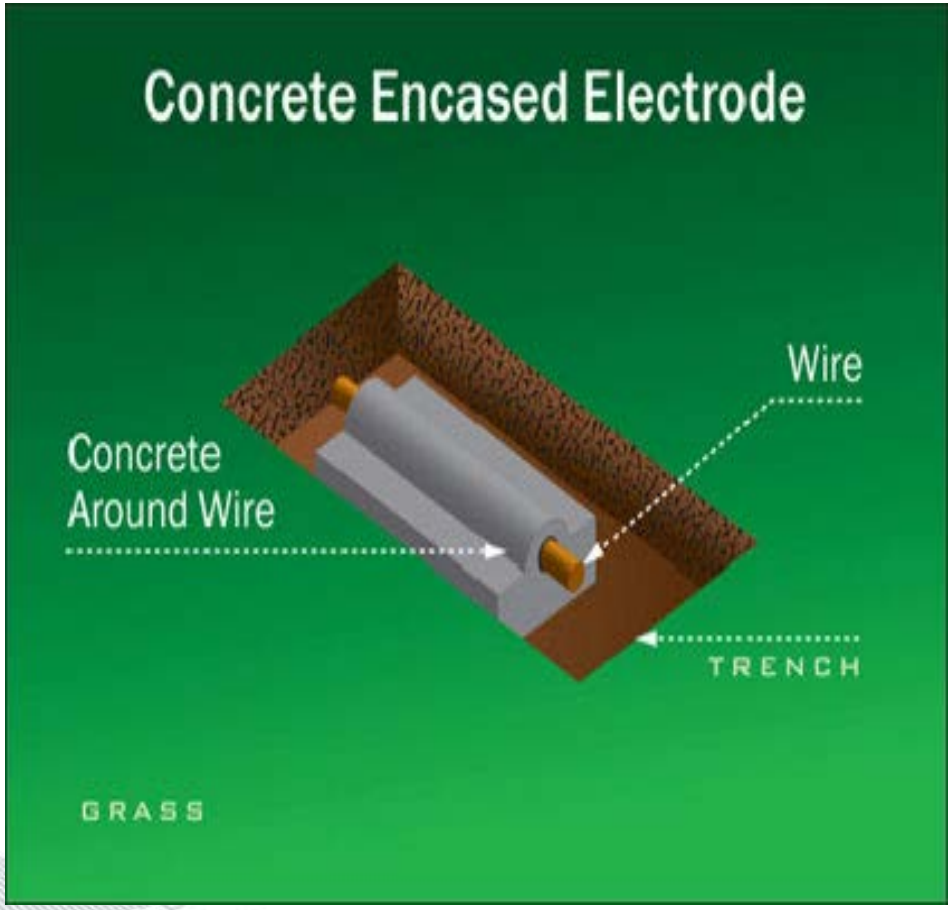
Conductor seen Through the inspection port (window)

Bicsi

1. Grounding Rods Plates & Pipes



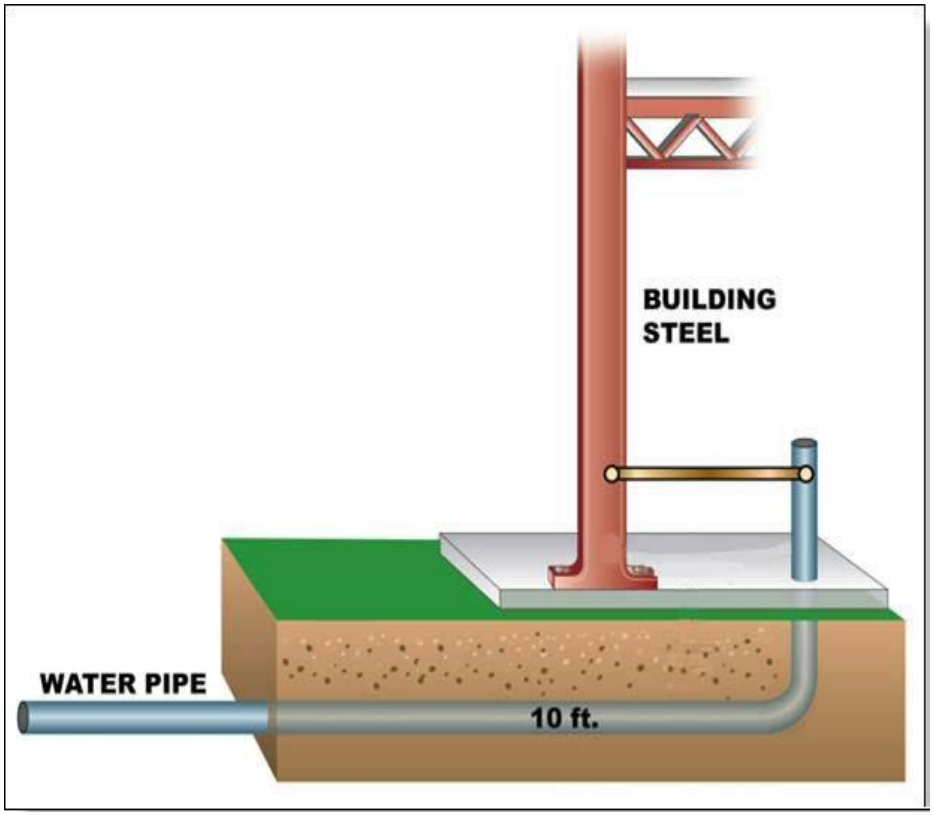
Copper Ground Rod



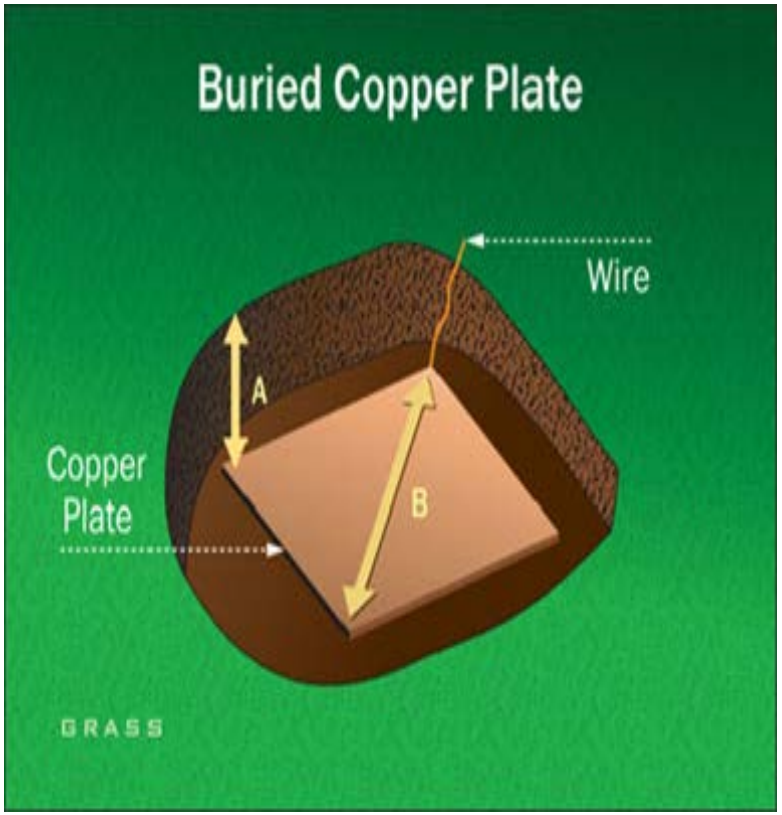
Ufer Grounding Method

Bicsi

1. Grounding Rods Plates & Pipes



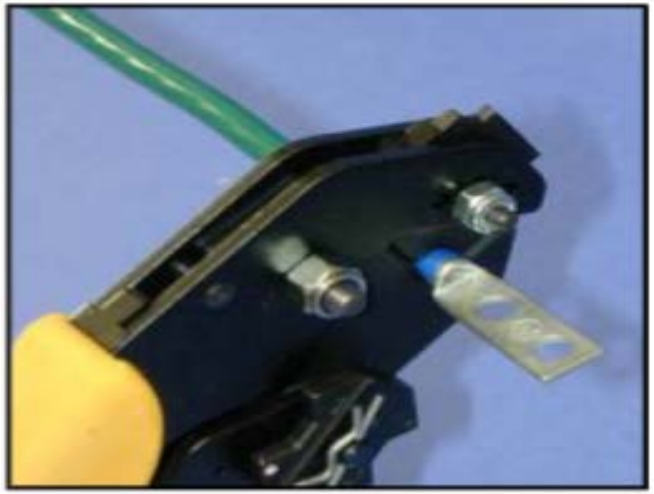
Building Frame & Water Pipe Bonding



Copper Plate Grounding

Bicsi

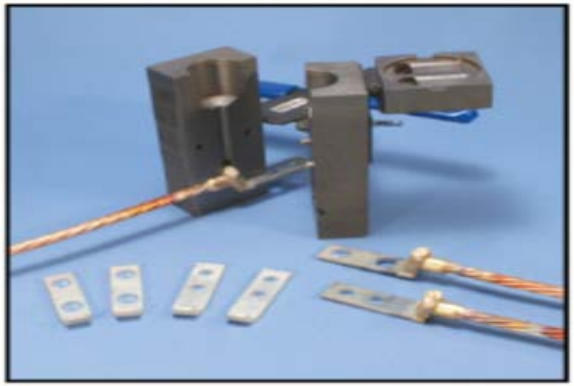
2. Preparations - Crimping & Exothermic Welding



Crimping a conductor in the barrel of the lug

Mold being locked and disk inserted

Finished Barrel with 3-crimps

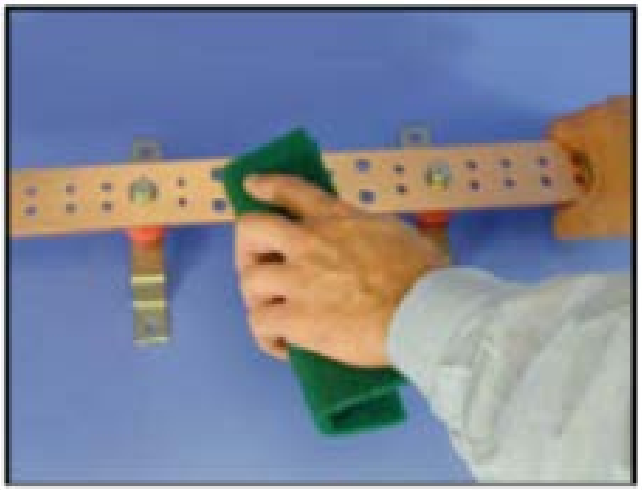


Example of a mold for an exothermic weld

Bicsi

2. Preparation - Exothermic Welding & Busbar

Pouring Weld metal powder into a mold



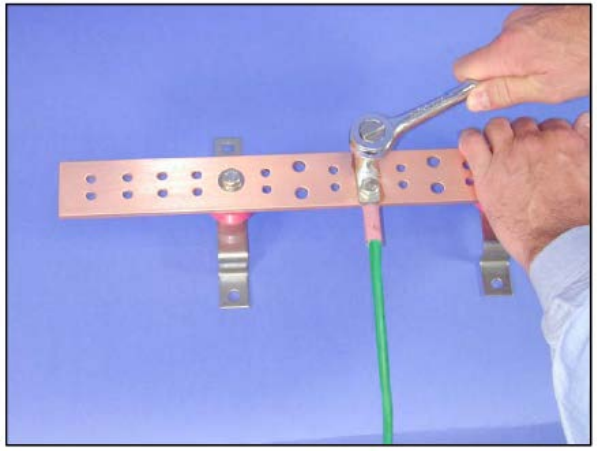
Removing oxidation from the grounding busbar

Igniting the accelerant

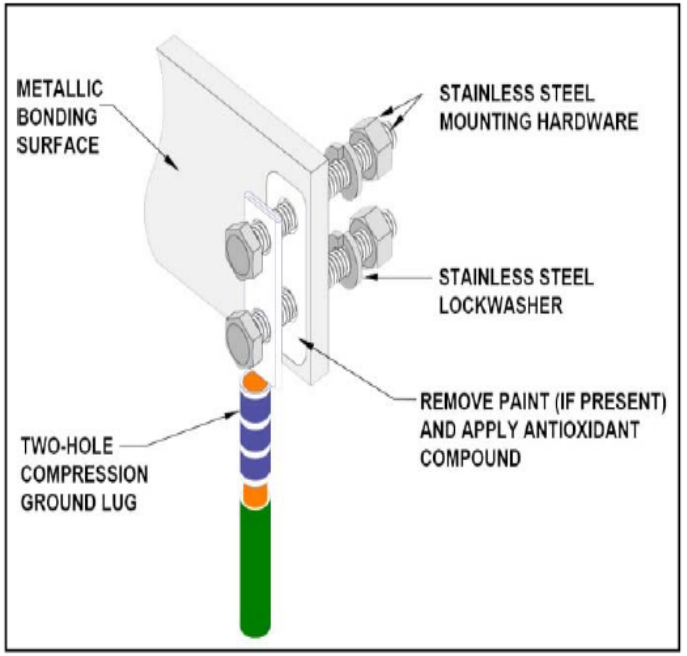
Applying an antioxidant to the cleaned area of the grounding busbar

Bicsi

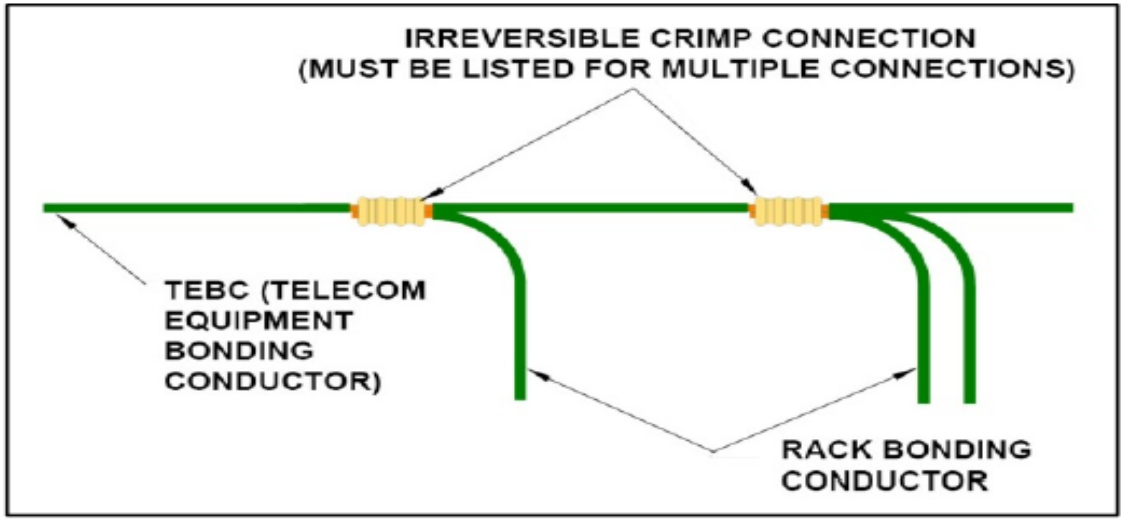
2. Preparation - Busbar Lug Connection



Attaching a lug to the grounding busbar



Lug mounting configuration



Example of a TEBC to Rack bonding conductor connection

3. Sample - Bonding Connection with Rack Cabinet Door System

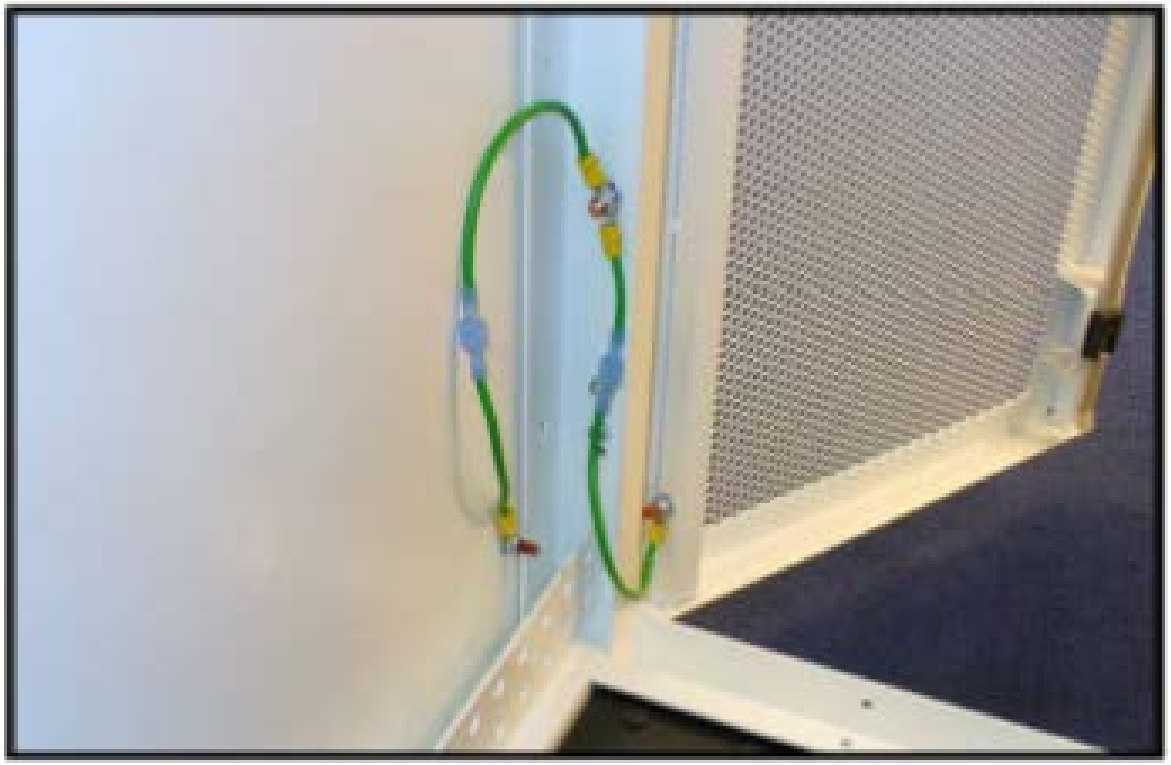


Illustration of a bond connection from a cabinet to the cabinet door & side panel

BICSI

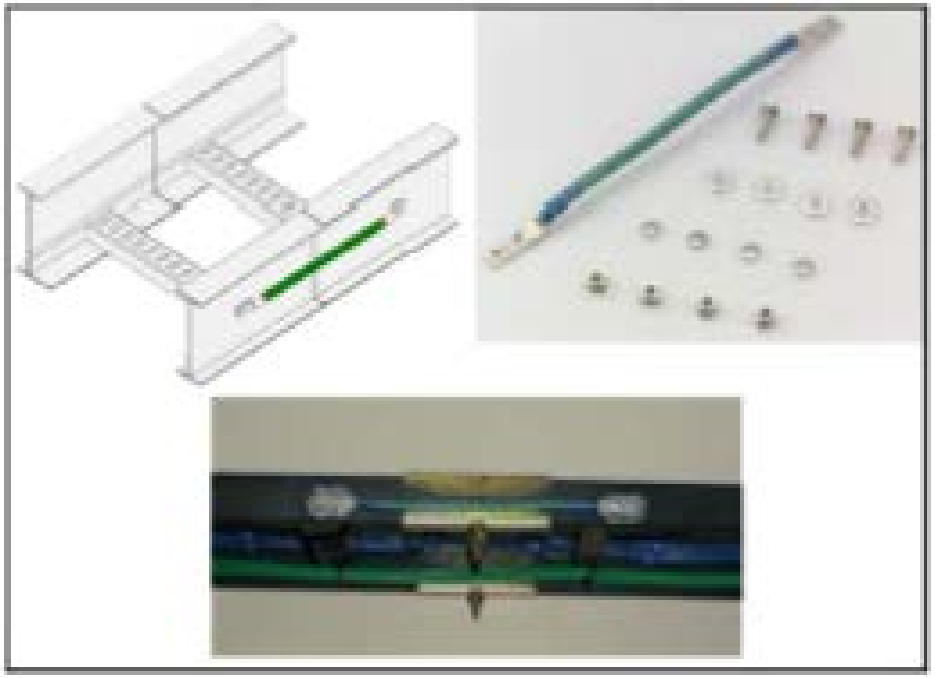
3. Sample - Mechanical & Exothermic Bonding Connection

Example of Mechanical Connector Shall Be UL listed for the purpose - Always

Example of Exothermic Welding

3. Sample - Mechanical Bonding on Trays

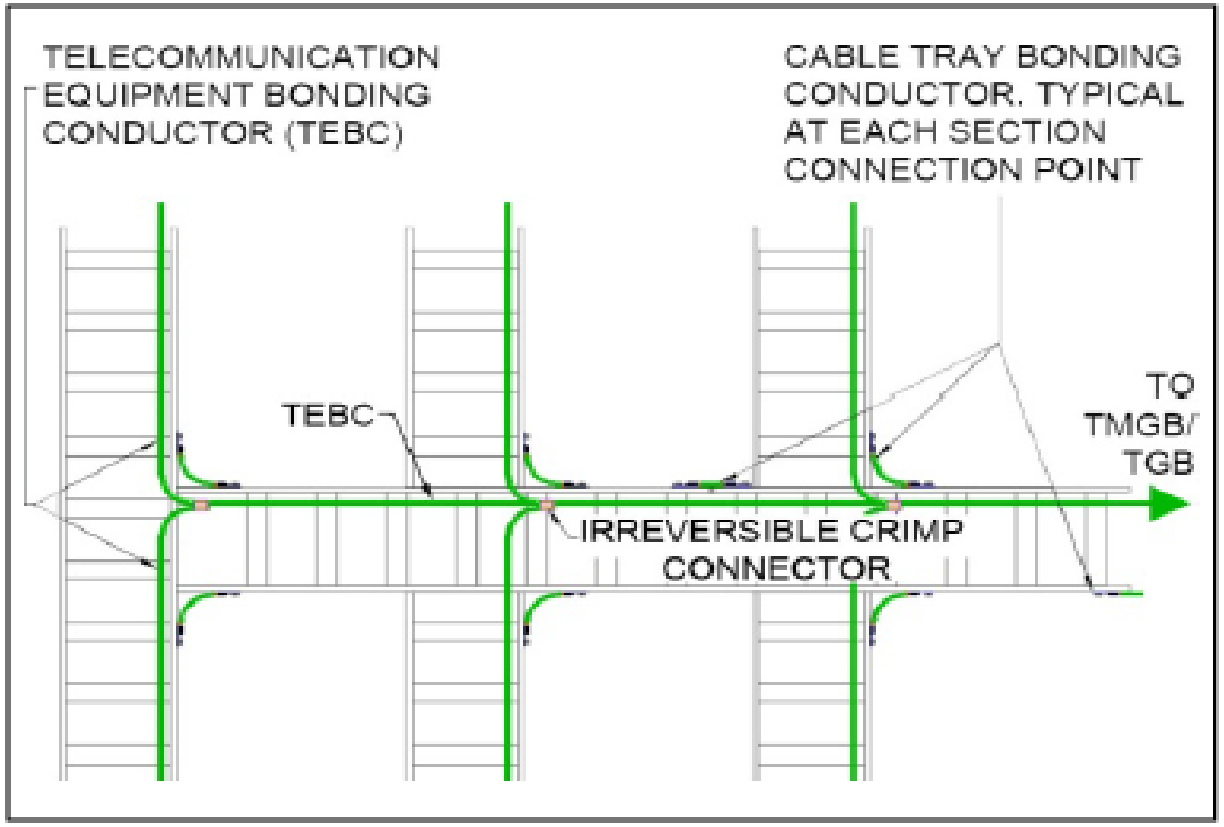
Example of 2-hole lugs and a ground terminal block & Clips



Example of bonding jumper and its installation between cable tray segments

Bicsi

3. Sample - Tray Bonding Routing & Radius



Example of a TEBC routed on a cable tray - bend radius shall not be less than 200mm & 90 degrees minimum

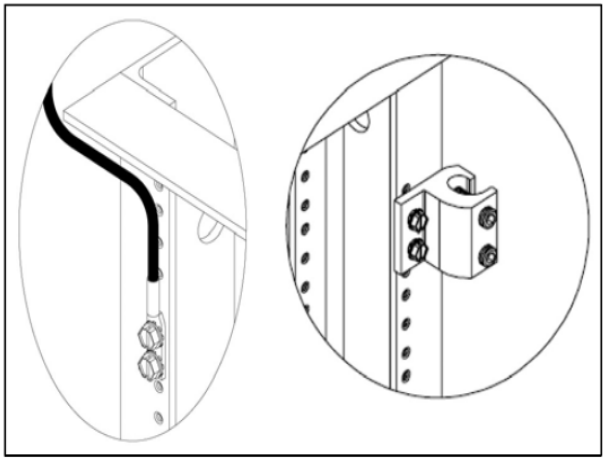
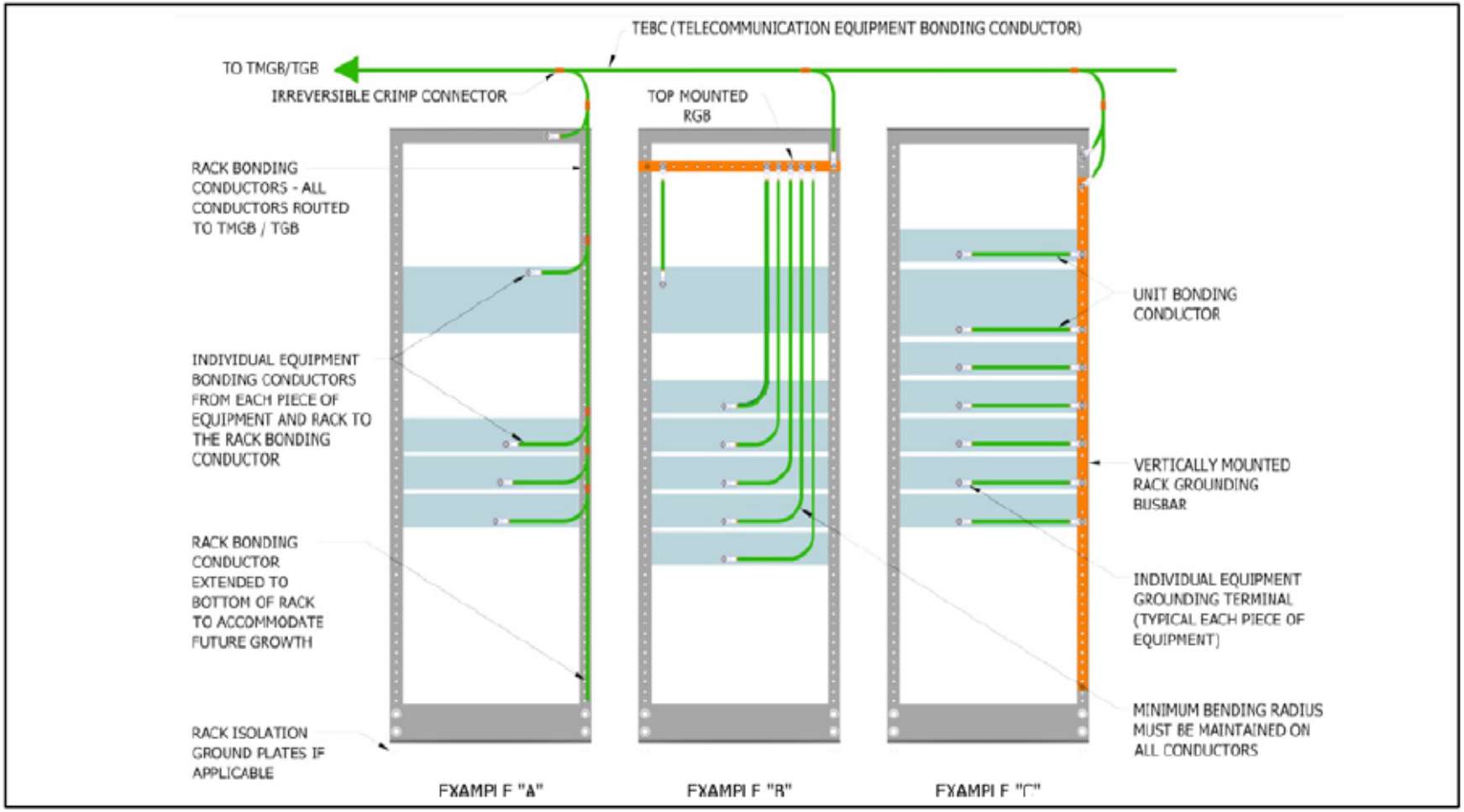


Illustration of a connection point to a rack from a TECB

BICSI

3. Sample - Rack Bonding Configurations



Three methods to bond equipment & racks to ground

3. Sample - Rack Bonding Configuration

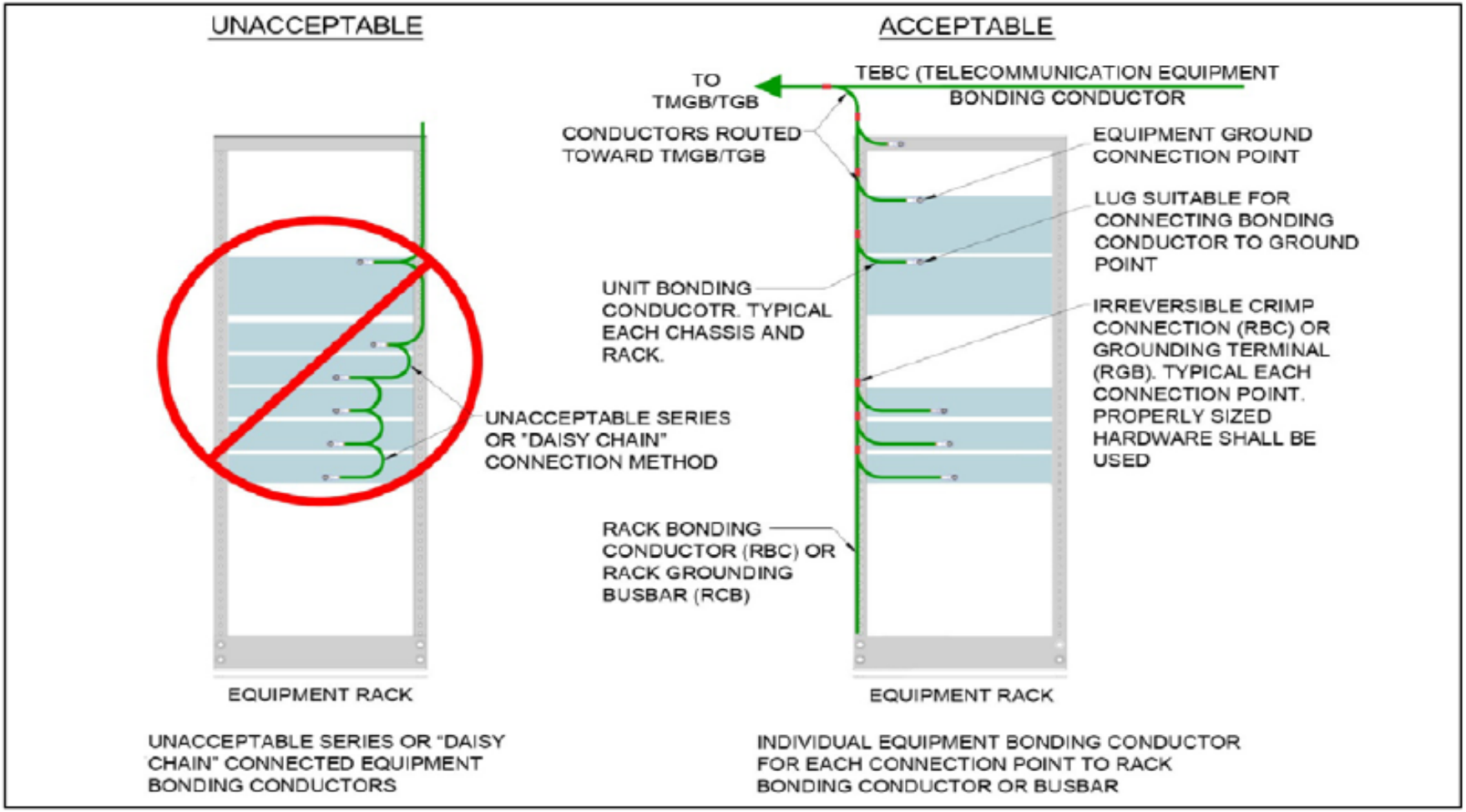
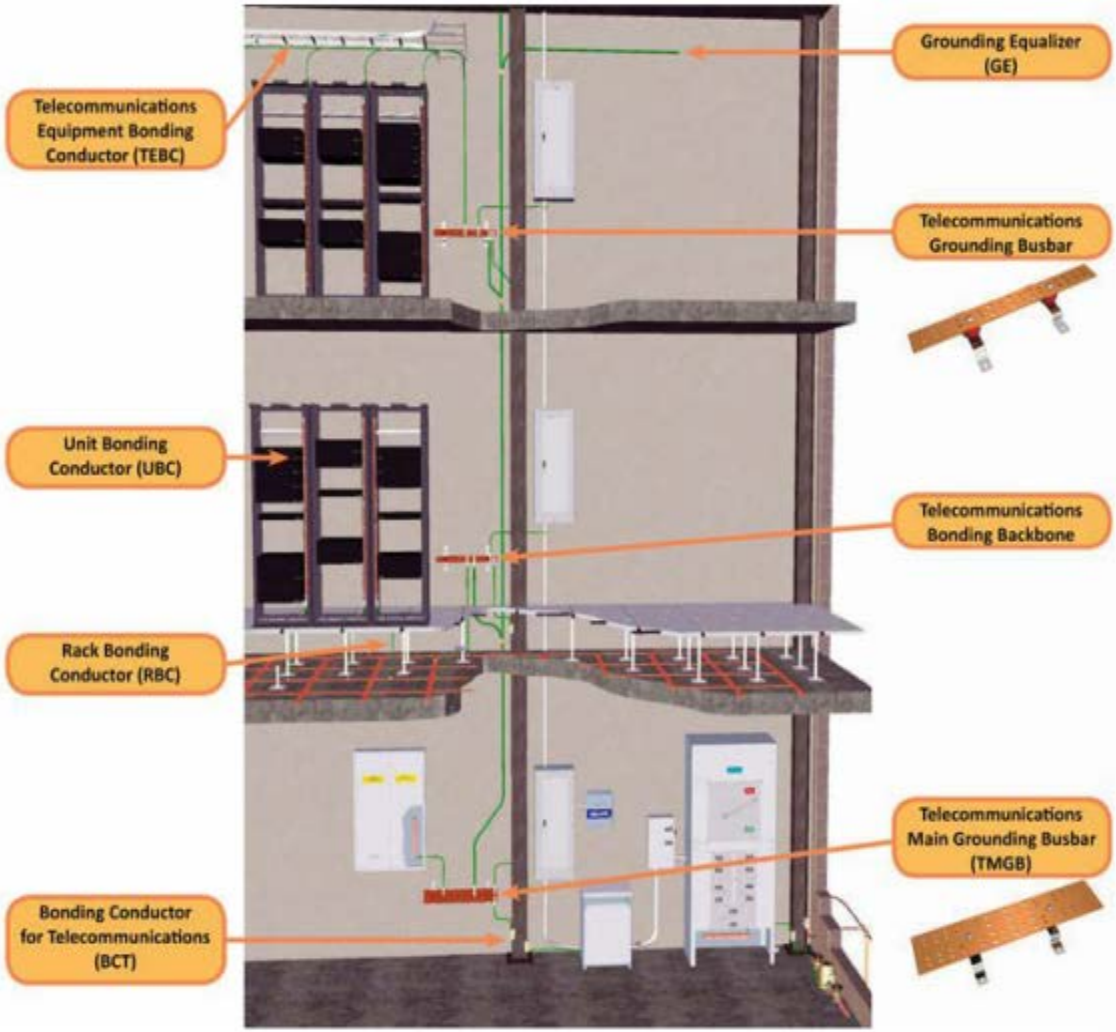


Illustration of acceptable and Unacceptable equipment bonding

4. Set Up - TGBB Grounding in an IT Room

TGBB should be closest possible to the Electrical Panels – Bond Everything!!

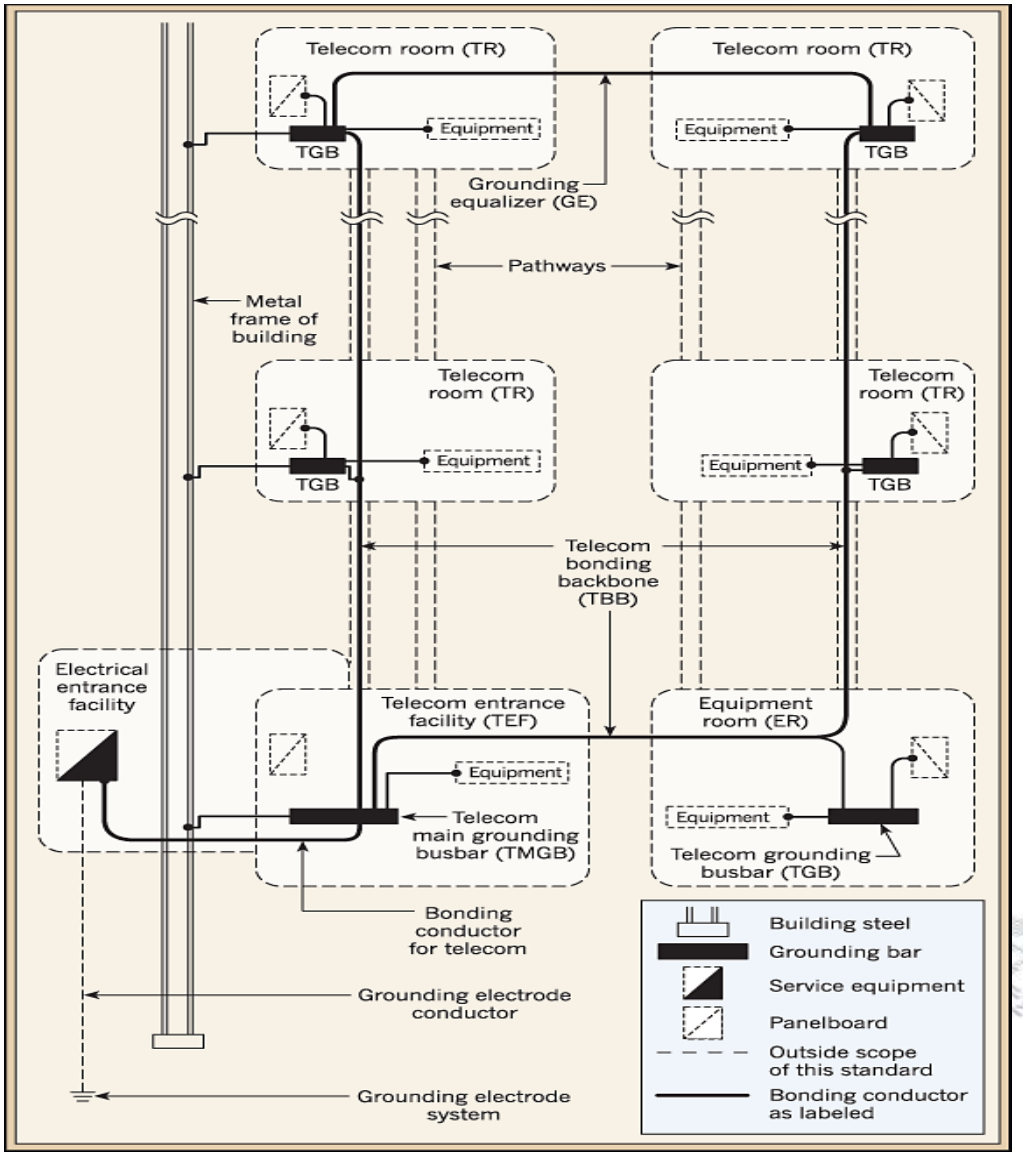
4. Set up - Components of grounding & Bonding System



Main components of the telecommunications bonding and grounding system

Supplemental bonding grid, or signal reference grid, found in raised-floor systems

4. Set up - Components of grounding & Bonding System ISO/IEC Referenced



Note that on the ISO/IEC 30129 (released Oct 2015) Standard for Information Technology : Telecommunications Bonding Networks for Buildings and other structures – GEs (Also known as Bonding Equalizer) must be made every other 3 floors and the top floor.

Bicsi

5. Sizing Up all Conductors – Main Bonding Conductors & Bonding Jumpers

TIA 607-B & ISO/IEC 30129

Maximum TMGBB (PBB) to TGBB (SBB) Length (L) meters (feet)	Conductor cross-sectional area (minimum)	
	Nominal Int'l Conductor (mm2)	Nominal AWG Conductor
L ≤ 4m (13ft)	16	6
4 < L ≤ 6m (14 – 20ft)	25	4
6 < L ≤ 8m (21 – 26ft)	35	3
8 < L ≤ 10m (27 – 33ft)	35	2
10 < L ≤ 13m (34 – 41ft)	50	1
13 < L ≤ 16m (42 – 52ft)	60	1/0
16 < L ≤ 20m (53 – 66ft)	70	2/0
20 < L ≤ 26m (67 – 84ft)	95	3/0
26 < L ≤ 32m (85 – 105ft)	120	4/0
32 < L ≤ 38m (106 – 125ft)	150	250 kcmil
38 < L ≤ 46m (126 – 150ft)	150	300 kcmil
46 < L ≤ 53m (151 – 175ft)	185	350 kcmil
53 < L ≤ 76m (176 – 250ft)	250	500 kcmil
76 < L ≤ 91m (251 – 300ft)	300	600 kcmil
Greater than 91m (301ft)	400	750kcmil

For lengths in excess of those shown above, the conductor cross-sectional area should be calculated as 3.3mm2/m or 2kcmil/ft.

BICSI

5. Sizing Up all Conductors – Bonding Conductors or Bonding Jumpers

Main incoming circuit-breaker rating (Amps)	Minimum number of Earth Electrodes	Minimum size of main Earth Conductor (mm^2)
60/100	1	16
200	1	50
300	1	50
400	1	70
500	2	70
600	2	70
800	2	70
1000	2	70
1600	2	70
2000	2	150
2500	2	150

5. Sizing Up all Conductors – Bonding Conductors or Bonding Jumpers

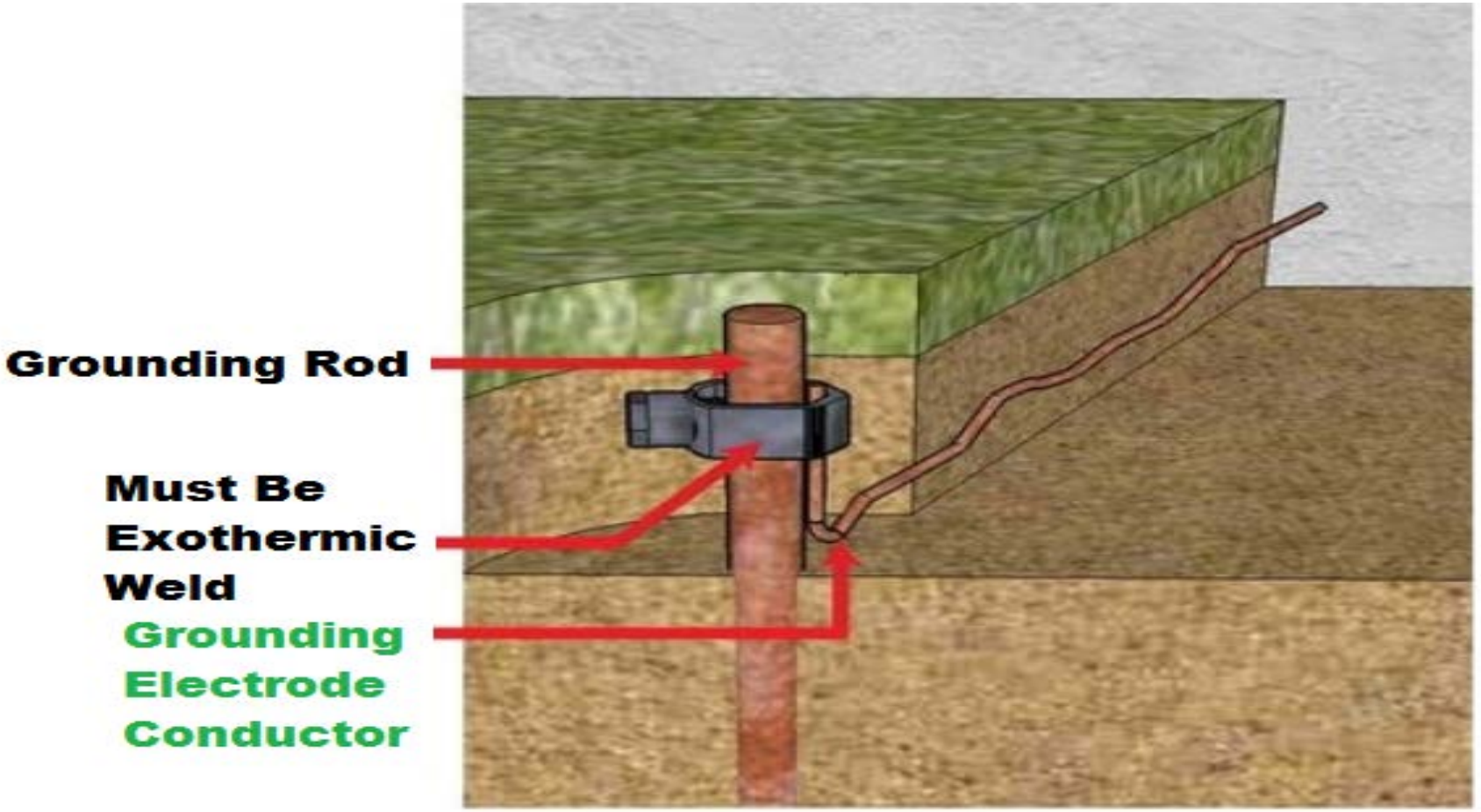
Cross sectional area of phase and neutral conductors (S) (mm^2)	Minimum cross-sectional area of Earth conductors [see note 1] (mm^2)	Minimum cross-sectional area of equipotential bonding conductors (mm^2)
S <= 16	S (not less than 1.5 see note 2)	S / 2 (not less than 4 or 6, see note 3)
16 < S <= 35	16	10
S > 35	S / 2	S / 4 (but not exceeding 25)

A5(j) Sizing of Earth Conductors and Equipotential Bonding Conductors

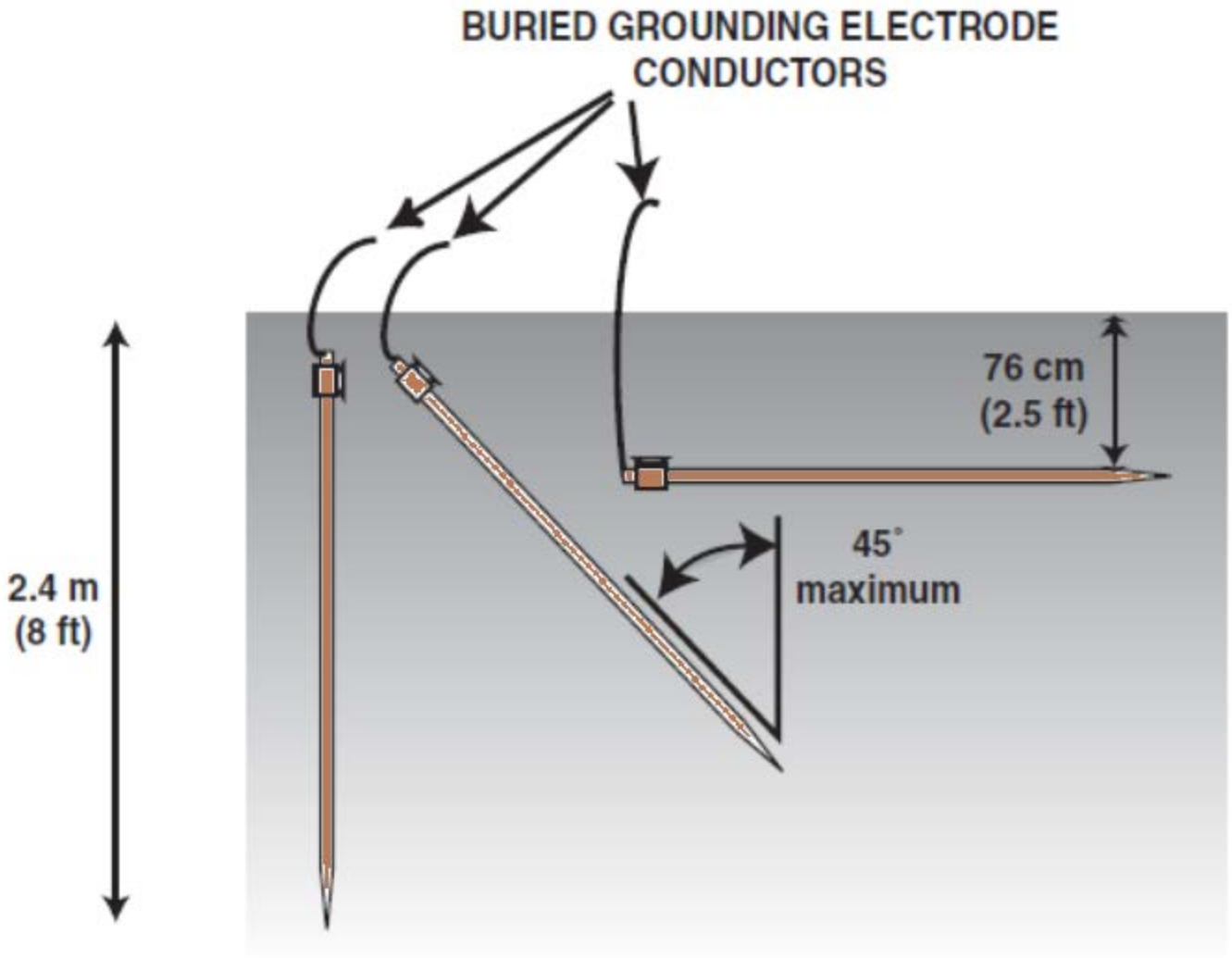
[from table 54.7 of BS 7671]

Bicsi

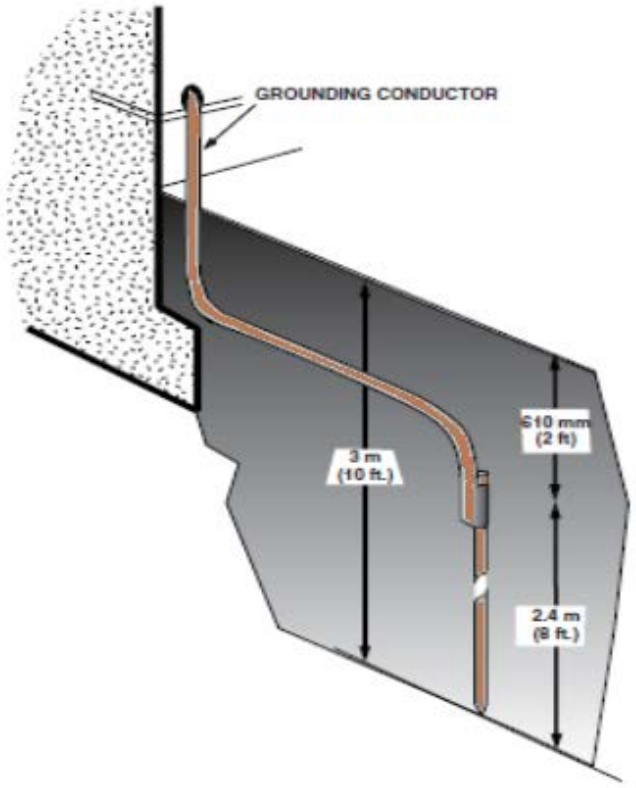
5. Sample Conductor – Main Grounding Electrode Conductor



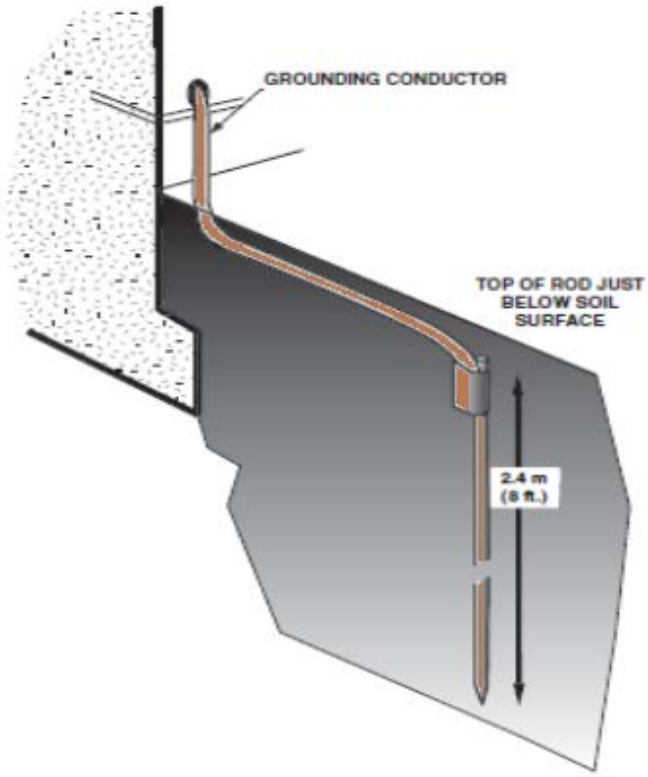
5. How to do It :
Main Grounding Electrode - Position



5. How to do It :
Main Grounding Electrode - Depth



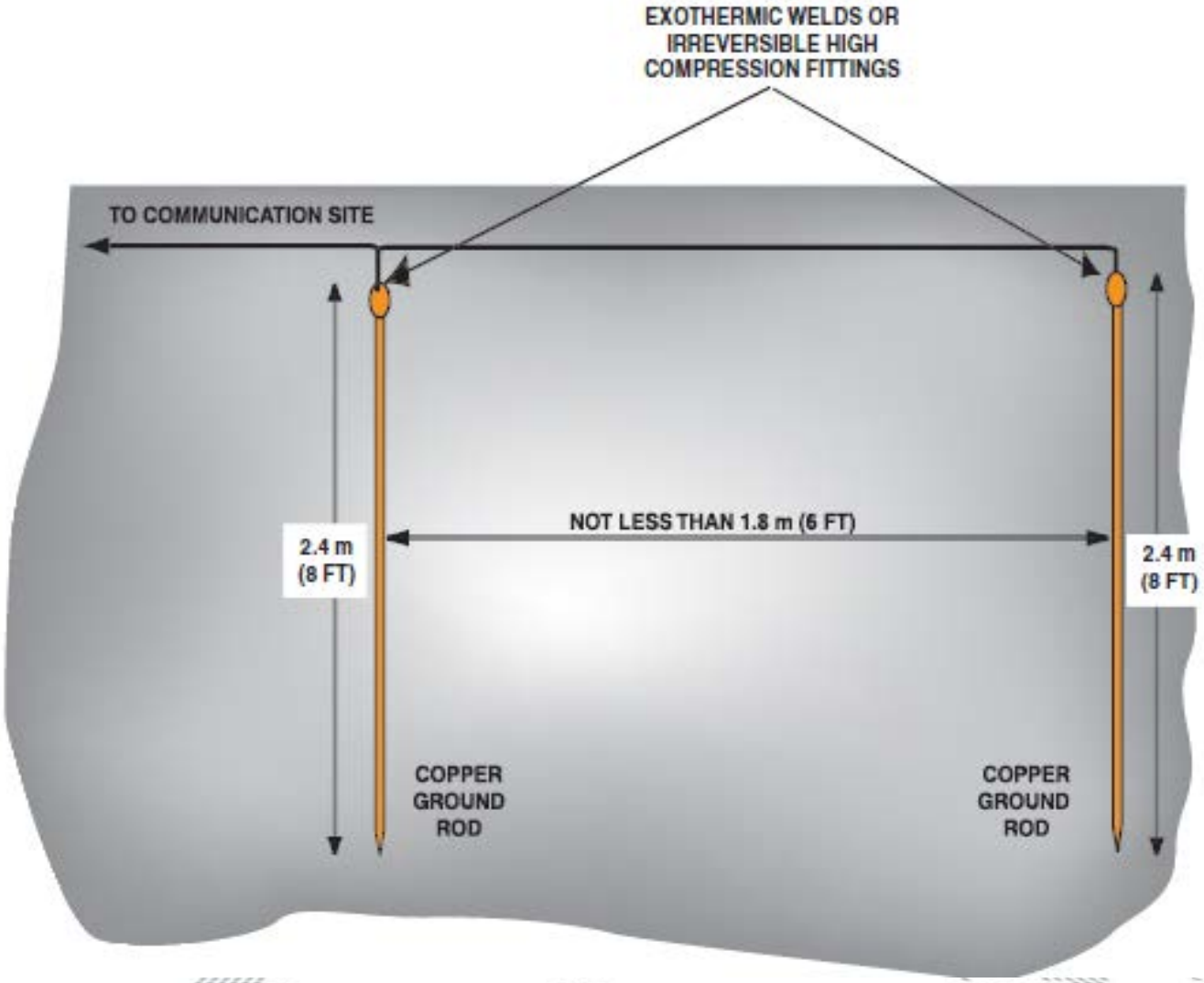
RECOMMENDED DEPTH



MINIMUM DEPTH

Bicsi®

5. How to do It :
Main Grounding Electrode - Spacing



DEWA = 6 meters apart Minimum

NPFA 70 = equal to the length of the Rod – minimum, with recommended spacing of twice the length of the Rod

DEWA = Dubai Electric & Water Authority

6. Testing – What numbers to look at?

Typical Ground Resistance Requirements – Which one to Follow!

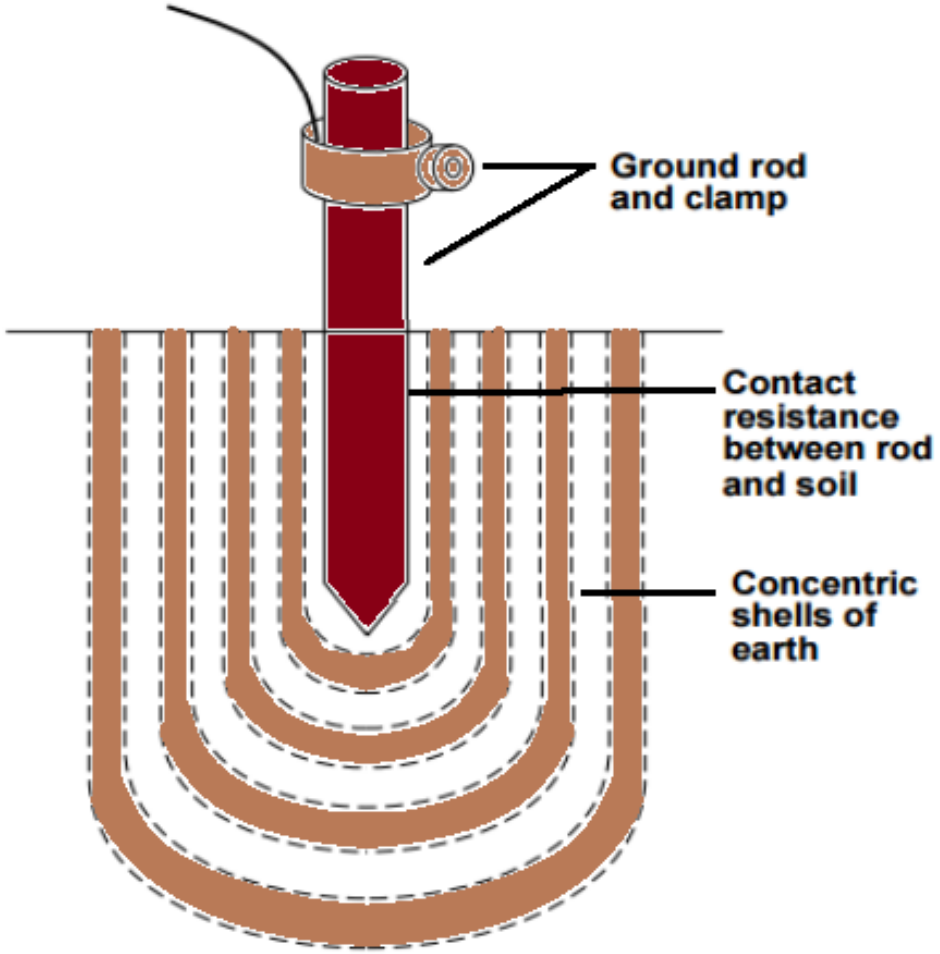
Type "A" Sites: (One Rod or Two Rods Grounding Systems)

- NFPA 70:2017 (NEC) = 25 Ohms or use two rods or more

Type "B" Sites: (Two or more Rods Grounding Systems in ring/radial or special set up)

- IEEE Standard 1100 = 1 Ohm (125Vac L-G) USA
  = 0.8 Ohm (277Vac L-G) USA
  = 0.8 Ohm (347Vac L-G) Canada
- Motorola Standard R56 = 10 Ohms (Design Goal – 5 Ohms Recommended)
- Telecommunications Cos = 3 to 5 Ohms, Regional TELCOs Less than 10 Ohms
- GE & Other Medical Systems = 2 Ohms
- ANSI/BICSI 002:2014 = 5 Ohms Maximum, but recommends
  3 Ohms for Class F2 & F3 DC, and
  1 Ohm for Class F4 Data Centers Design
- DEWA - Dubai = 1 Ohm (Section 5.2.4 – 1997Ed)
- TEWR - Abu Dhabi = 10 Ohms (Section 6.2.1a – 2014ed)

6. Testing - Option 1 = Fall Of Potential Method



(Effective Resistance Area)

Components of resistances in an earth Electrode

Bicsi

6. Testing - Option 1 = Fall Of Potential Method

Reference: IEEE 81:2012 = Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System

How to Space the Current Probe from Electrode to be Tested?..... How Far!

On a Single Electrode

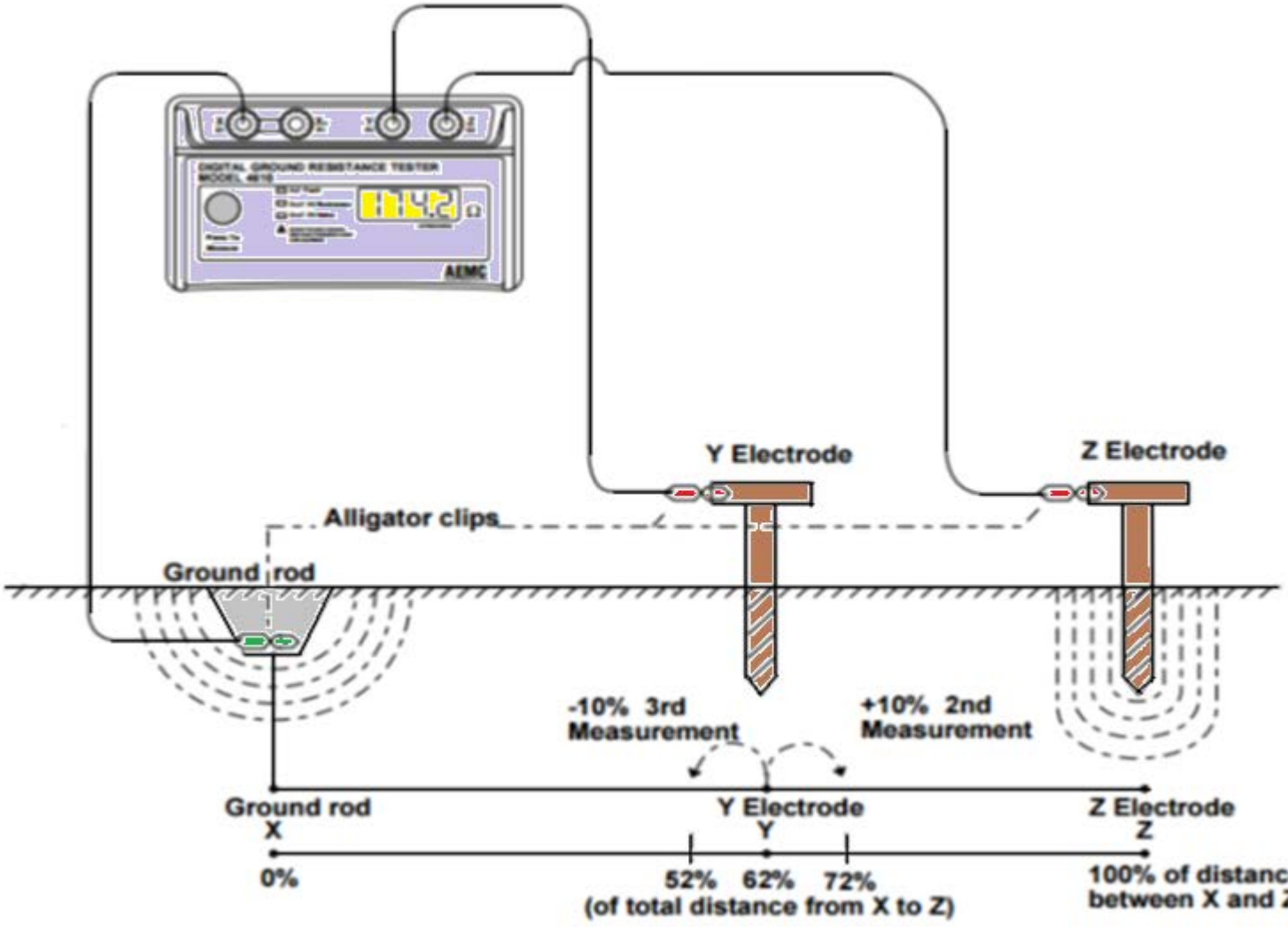
* **Minimum Distance = 5 Times the Length of the Rod**
* **Ideal? = 10 Times the Length of the Rod**

@ 10FT Rod, Current Probe = 100Feet Away

Note: **In numerous test on soil with uniform soil resistivity it has been found that ground's resistance is at around 62% (some documents says at 61.8%) away from the rod under test!! Hence Fall of Potential Method is also known as 62% Method of Ground Resistance Testing.**

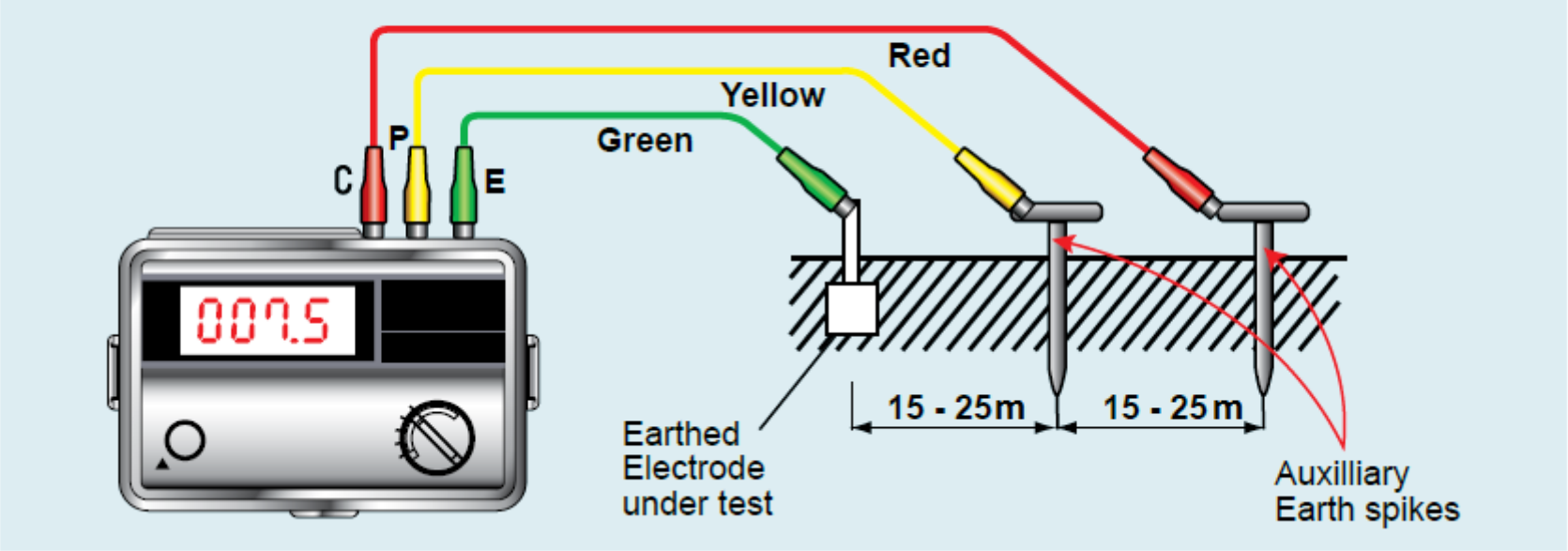
Bicsi

6. Testing - Option 1 = Fall Of Potential Method



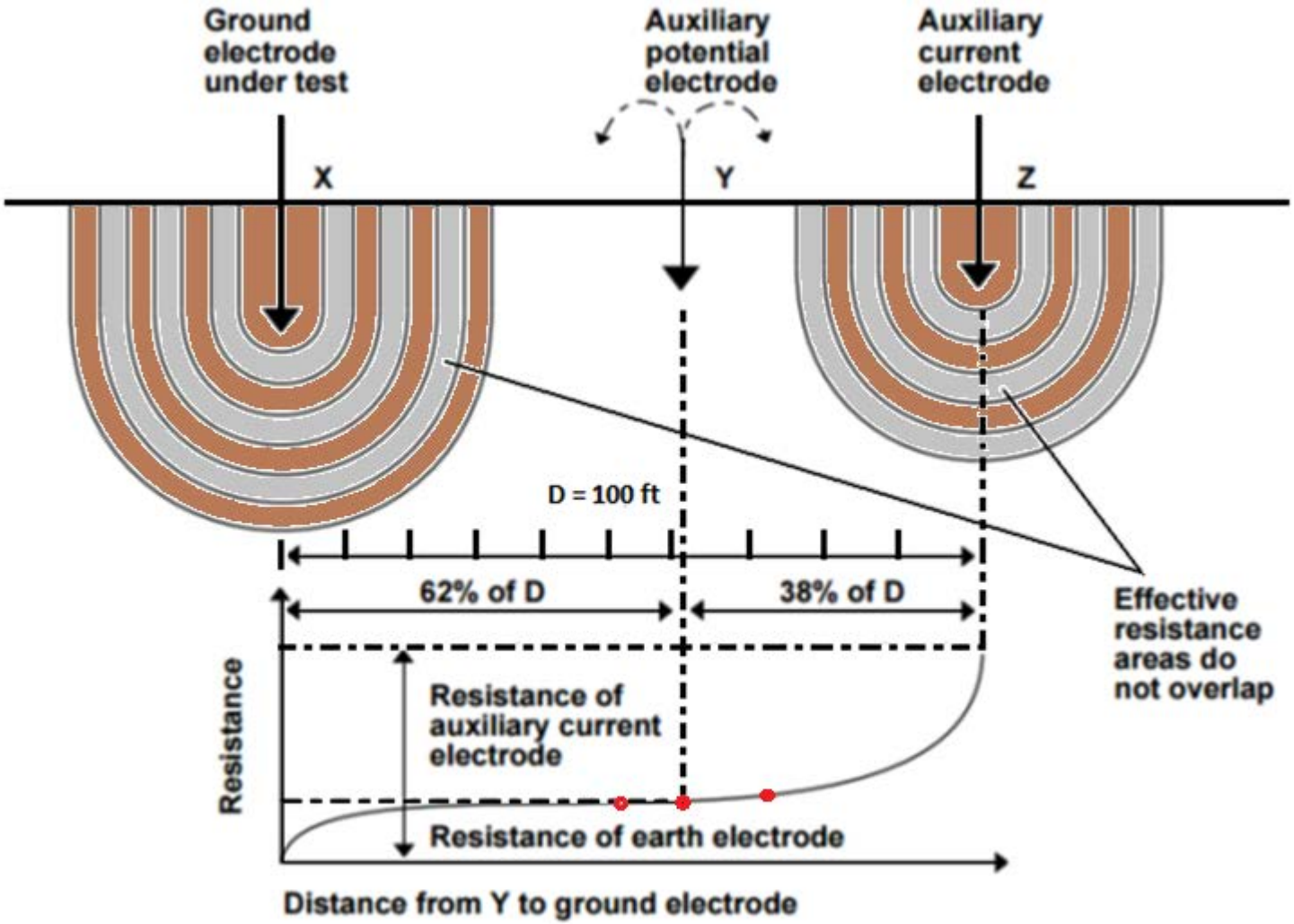
6. Testing - Option 1 = Fall Of Potential Method

Method 1: measurement using dedicated Earth Electrode tester

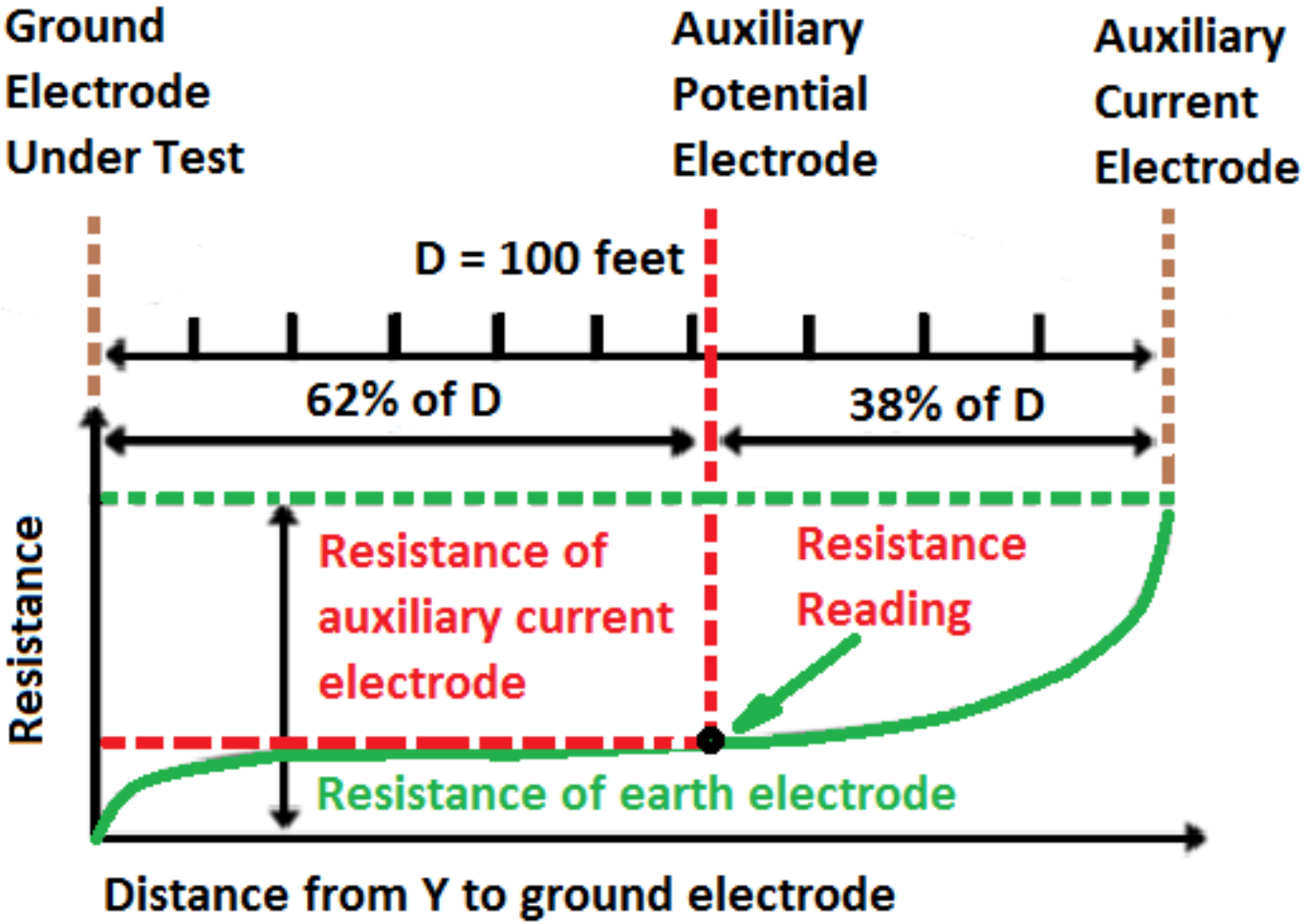


Abu Dhabi – The Electrical Wiring Authority
Manual (3rd Ed – 2014) Appendix A19(a)

6. Testing - Option 1 = Fall Of Potential Method



6. Testing - Option 1 = Fall Of Potential Method



6. Testing - Option 2 = Clamp-on Testing

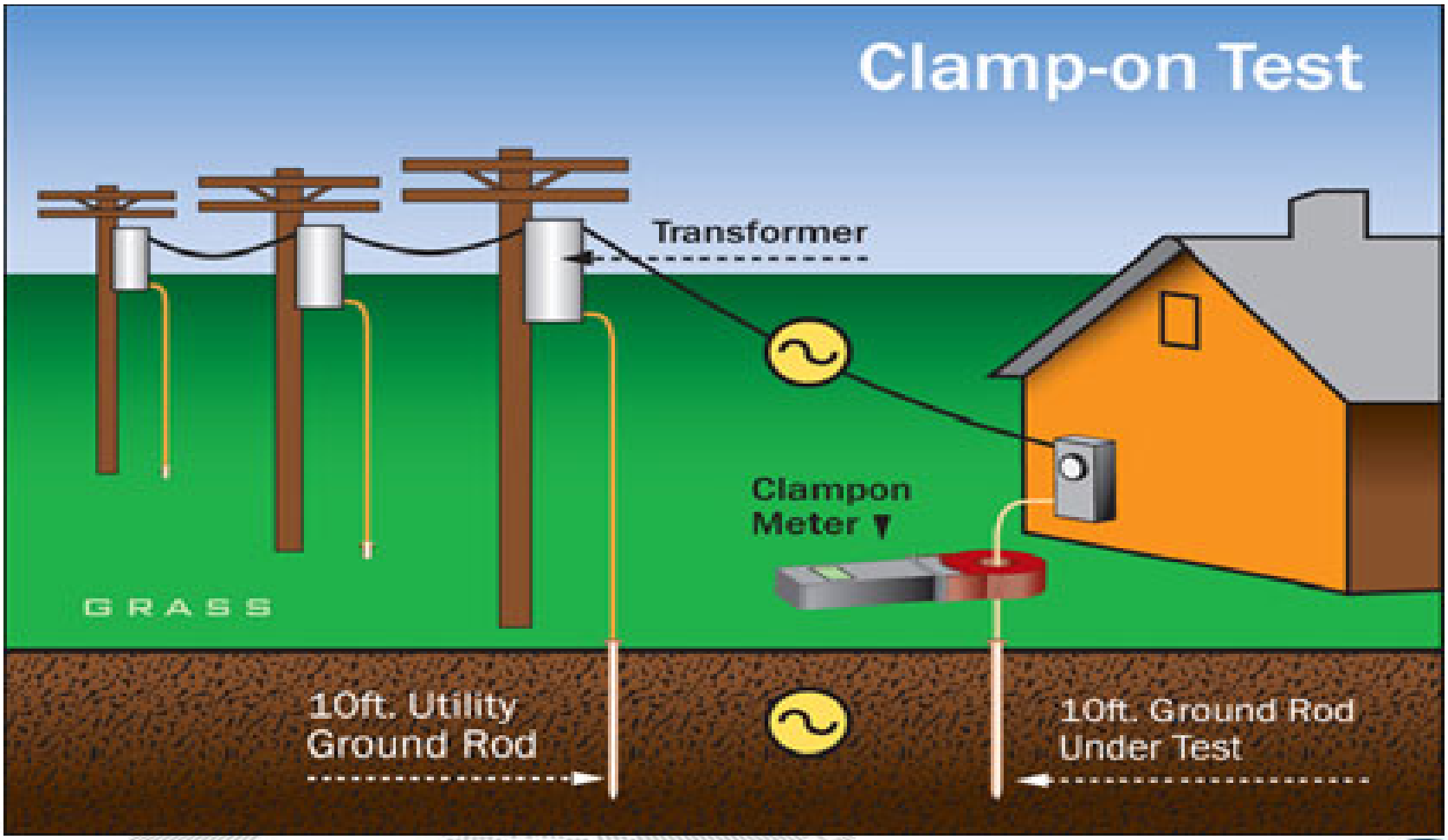
Clamp-on Ground Resistance Meter

* Does Not Require Disconnecting Equipment
* Measures Current on the Ground to get Ground Resistance,
* Referenced with Pole Butt Proper and consistent resistance, and
* Very Convenient, Quick & Easy

However, it may read Ground Loops instead of Ground Resistance!!

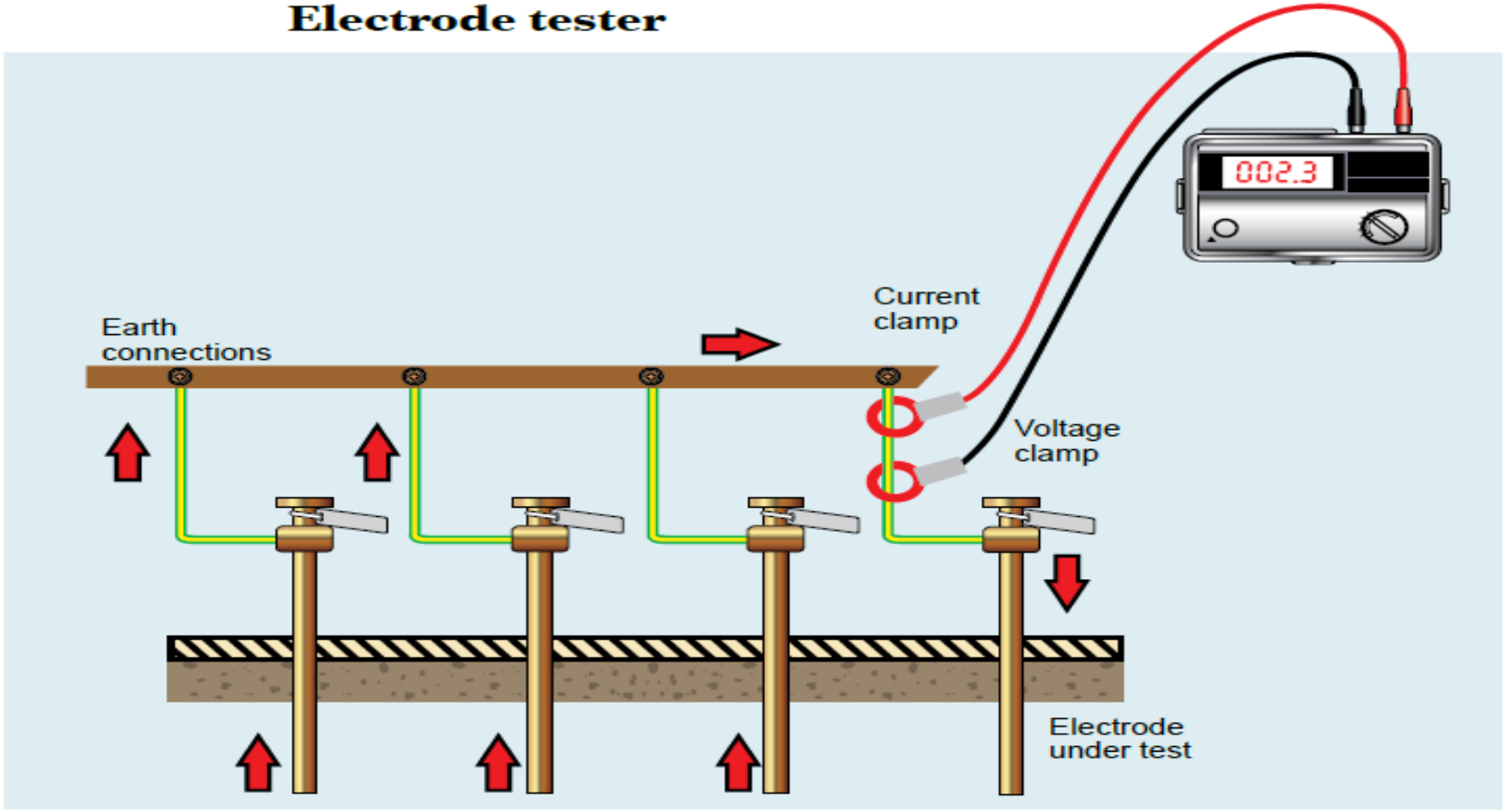
Bicsi

6. Testing - Option 2 = Clamp-on Testing



6. Testing - Option 2 = Clamp-on Testing

Method 2: measurement using dedicated stakeless Earth Electrode tester



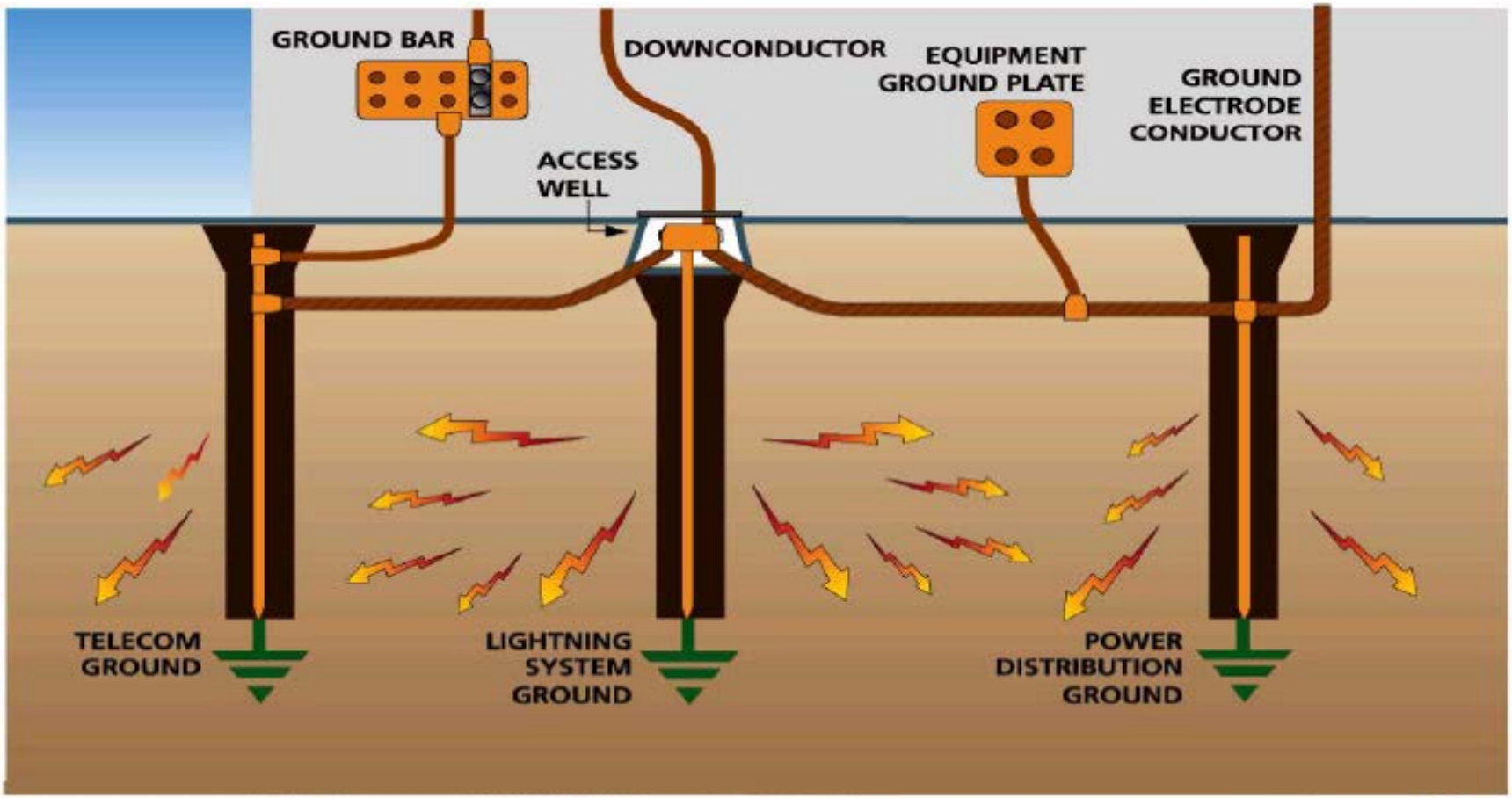
Abu Dhabi – The Electrical Wiring Authority Manual (3rd Ed – 2014) Appendix A19(a)

7. Bond it Together - Follow the Codes

NFPA 70:2017
Art 800 Communication Circuits
Section: 800.100(D)

Bonding of Electrodes. A bonding jumper not smaller than **6AWG (14mm2)** copper or equivalent shall be connected between the communications grounding electrode and power grounding electrode system at the building or structure served where separate electrodes are used.

7. The Key? – Just Bond It Together!



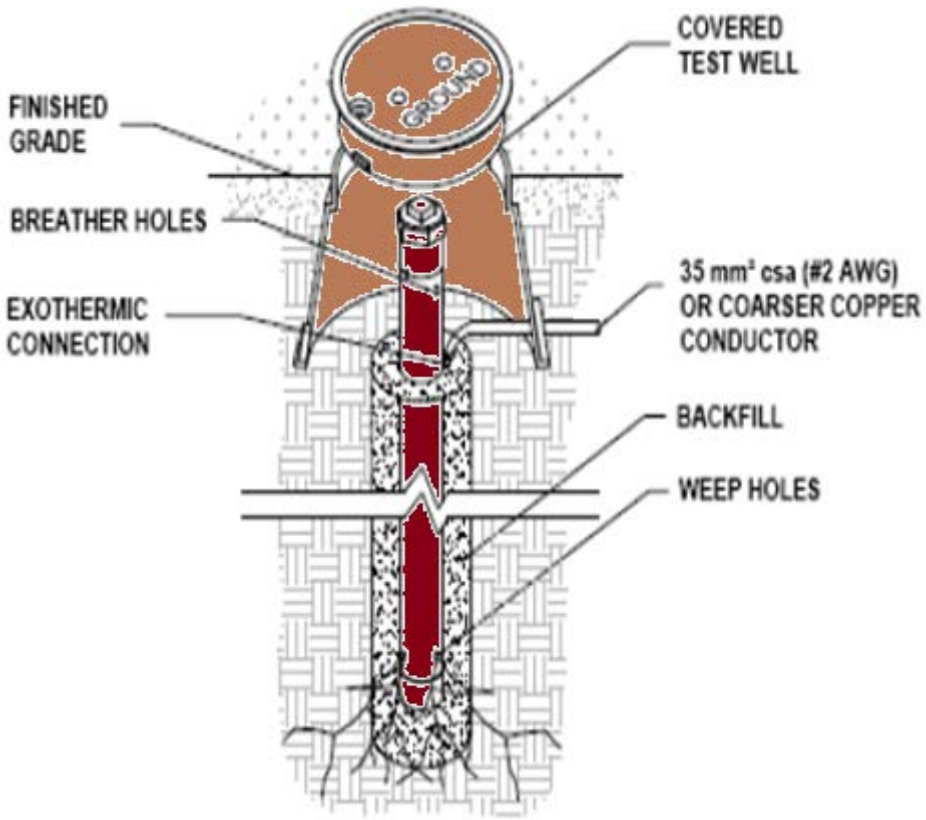
8. Area with Poor Soil Conductivity

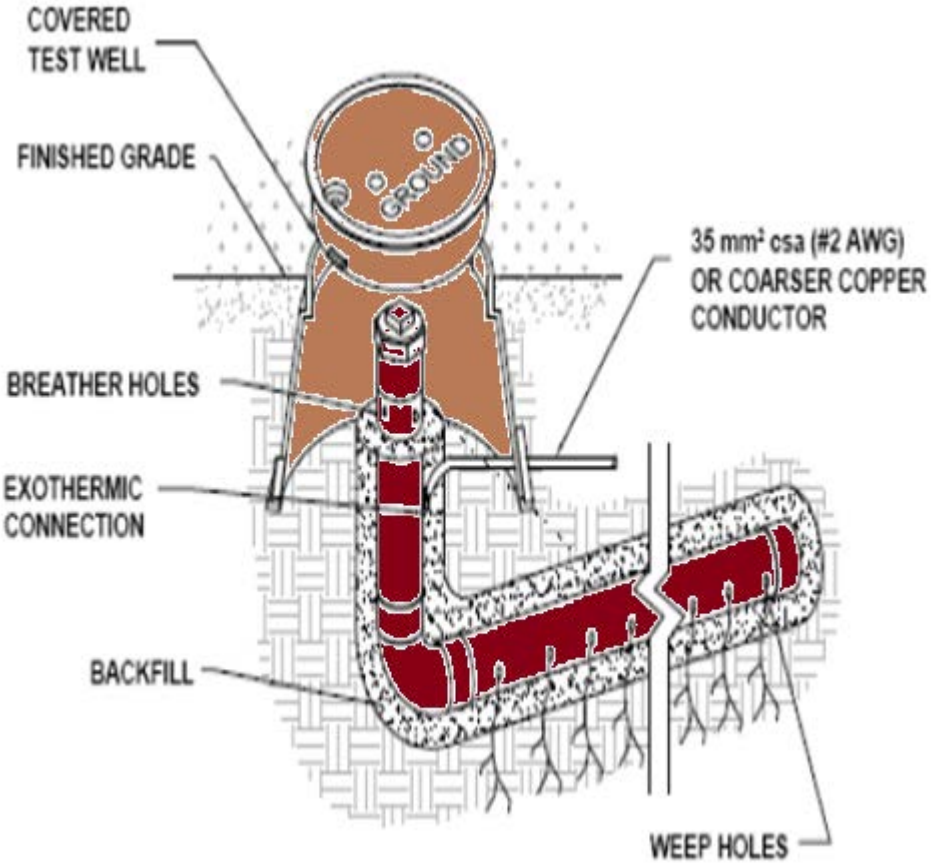
Option 1: Electrolytic Grounding Rod Systems

- **Commercially available electrolytic ground rods should be considered.** (MIL-HDBK-419A Volume I, and UL 467-2013)
- **These are in straight or L-shaped versions. Generally constructed of 54 mm (2.125 in.) dia. hollow copper pipe and filled with a mixture of non-hazardous natural earth salts.**
- **Holes on the pipe allow moisture to be hygroscopically extracted from the air into the salt within the pipe, hence forming conductive electrolytes and leach out from the pipe into the soil, thus improving soil conductivity.**
- **Electrolytic ground rods are inserted into a pre-drilled hole, or in the case of L-shaped rods, placed into a trench at least 762 mm (30 in.) deep, and encased in a grounding electrode encasement material.**

8. Area with Poor Soil Conductivity

Option 1: Electrolytic Grounding Rod Systems





Bicsi®

8. Area with Poor Soil Conductivity

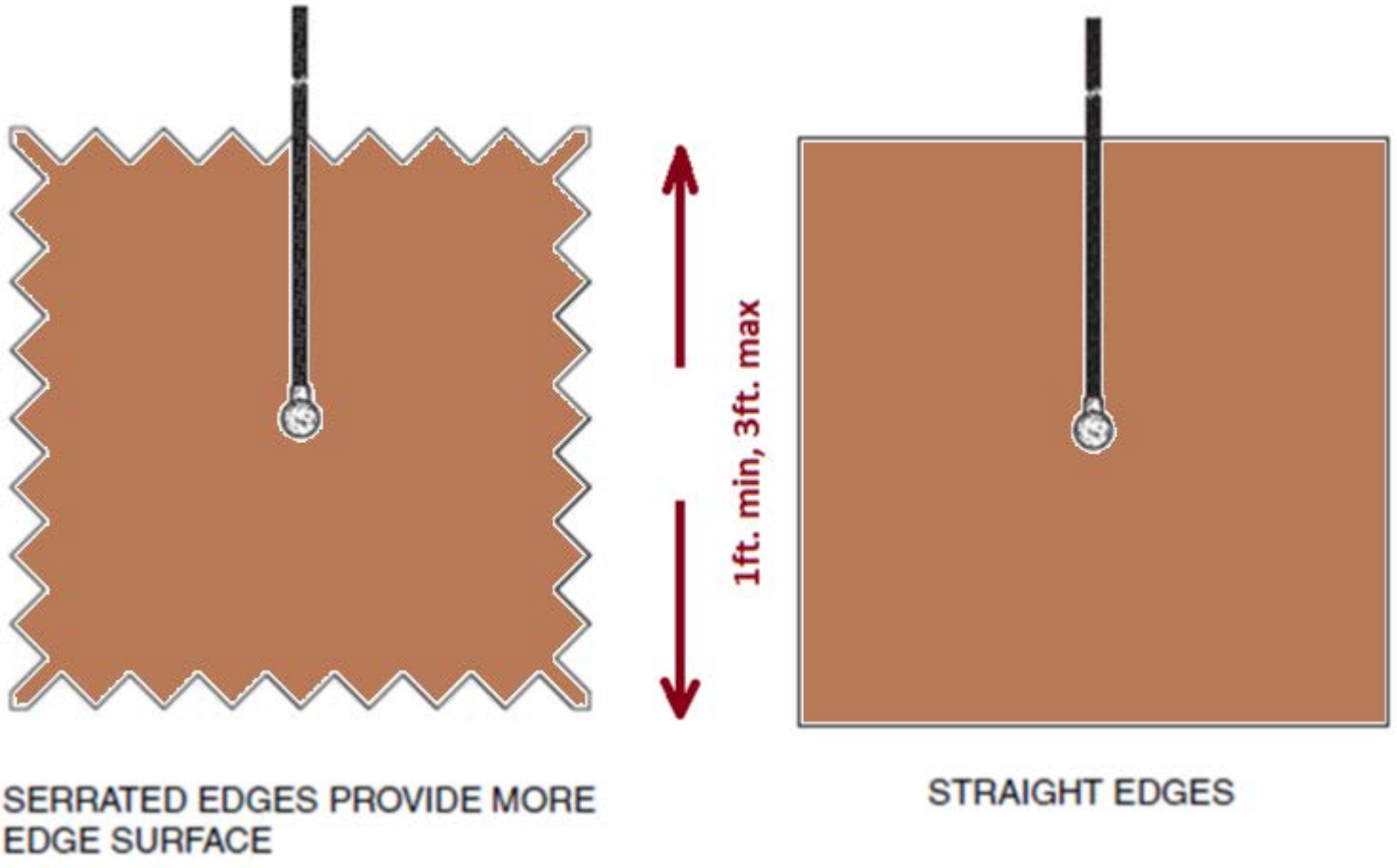
Option 2: Copper Plates Grounding Systems

Requirements and use of ground plate electrodes are as follows:

- Ground Plates shall be UL listed using copper or copper-clad steel plates.
- It shall expose not less than 0.37 m2 (2 sq.ft.) of surface to exterior soil (MIL-HDBK-419A, NFPA 70-2017, & NFPA 780-2017).
- It shall have a minimum thickness of 1.5 mm (0.06 in.) (MIL-HDBK-419A, & NFPA 70-2017).
- Ground plates shall be free of paint or other nonconductive coatings (NFPA 70-2017, & NFPA 780-2017).
- It shall be buried not less than 762 mm (30 in.) below the surface of the earth (NFPA 70-2017).
- Where practical, a ground plate shall be embedded below permanent moisture level (BS 7430:1998, & NFPA 70-2017).
- Ground plates should be installed vertically to allow for minimum excavation and better contact with the soil when backfilling (BS 7430:1998 and IEEE STD 142-1991)

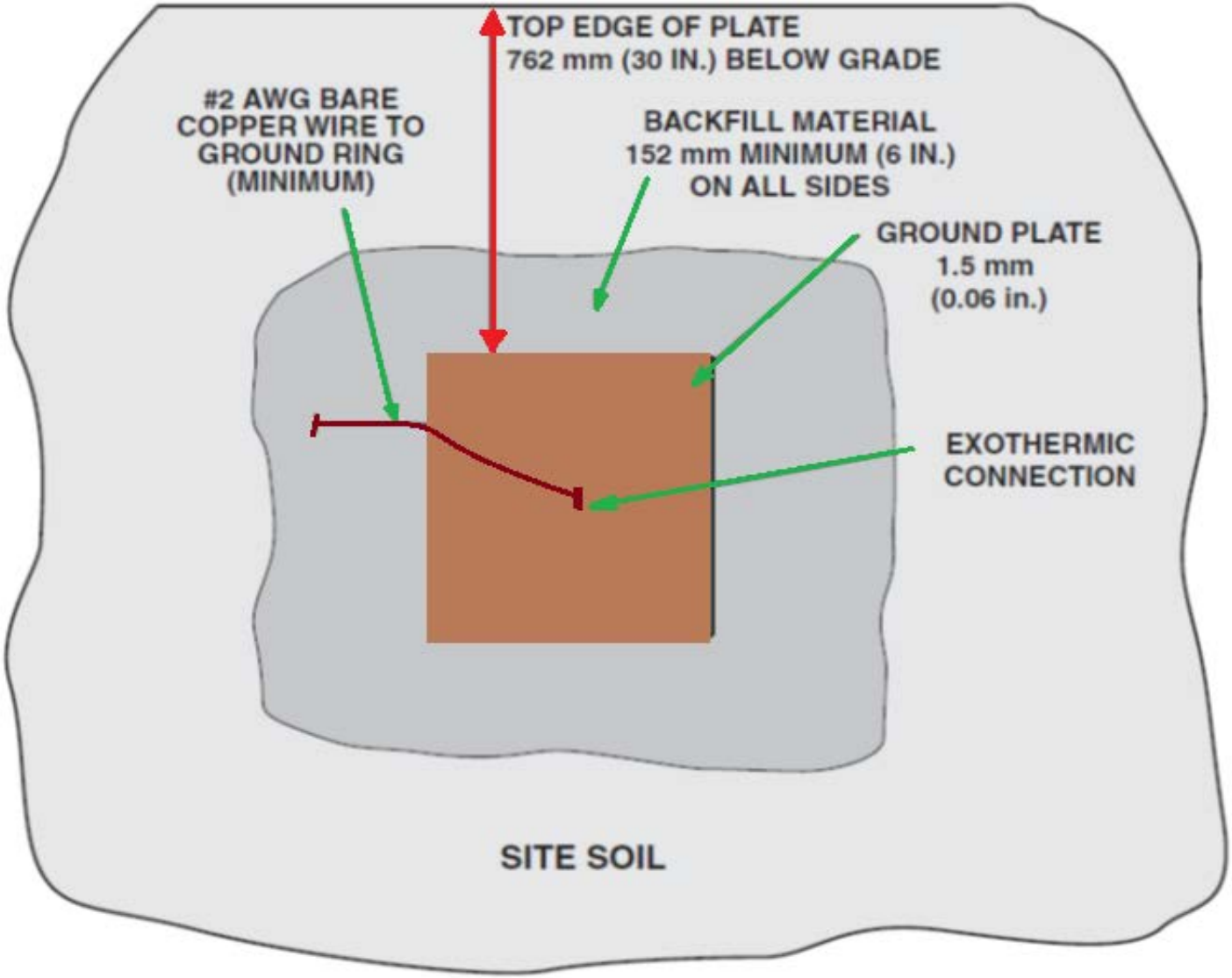
8. Area with Poor Soil Conductivity

Option 2: Copper Plates Grounding Systems



8. Area with Poor Soil Conductivity

Option 2: Copper Plates Grounding Systems



Bicsi

8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems

- **Though concrete-encased electrodes (also known as Ufer electrodes, or foundation earth electrodes - named after Herbert G. Ufer,), they should be used in new construction as a method of supplementing the grounding electrode system (IEC 62305-3).**

- **It enhance the effectiveness of the grounding electrode system in two ways:**
  - *** the concrete absorbs and retains moisture from the surrounding soil, and**
  - *** the concrete provides a much larger surface area in direct contact with the surrounding soil. (This is especially helpful at sites with limited area for installing a grounding electrode system).**

- **See IEEE STD 142-1991 section 4.2.3, and the International Association of Electrical Inspectors publication, Soares Book on Grounding and Bonding, 9th Edition, for added information.**

Bicsi

8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems

Requirements for a concrete encased electrode, if used, are listed as follows (IEC 62305-3, NFPA 70-2017, and NFPA 780-2017):

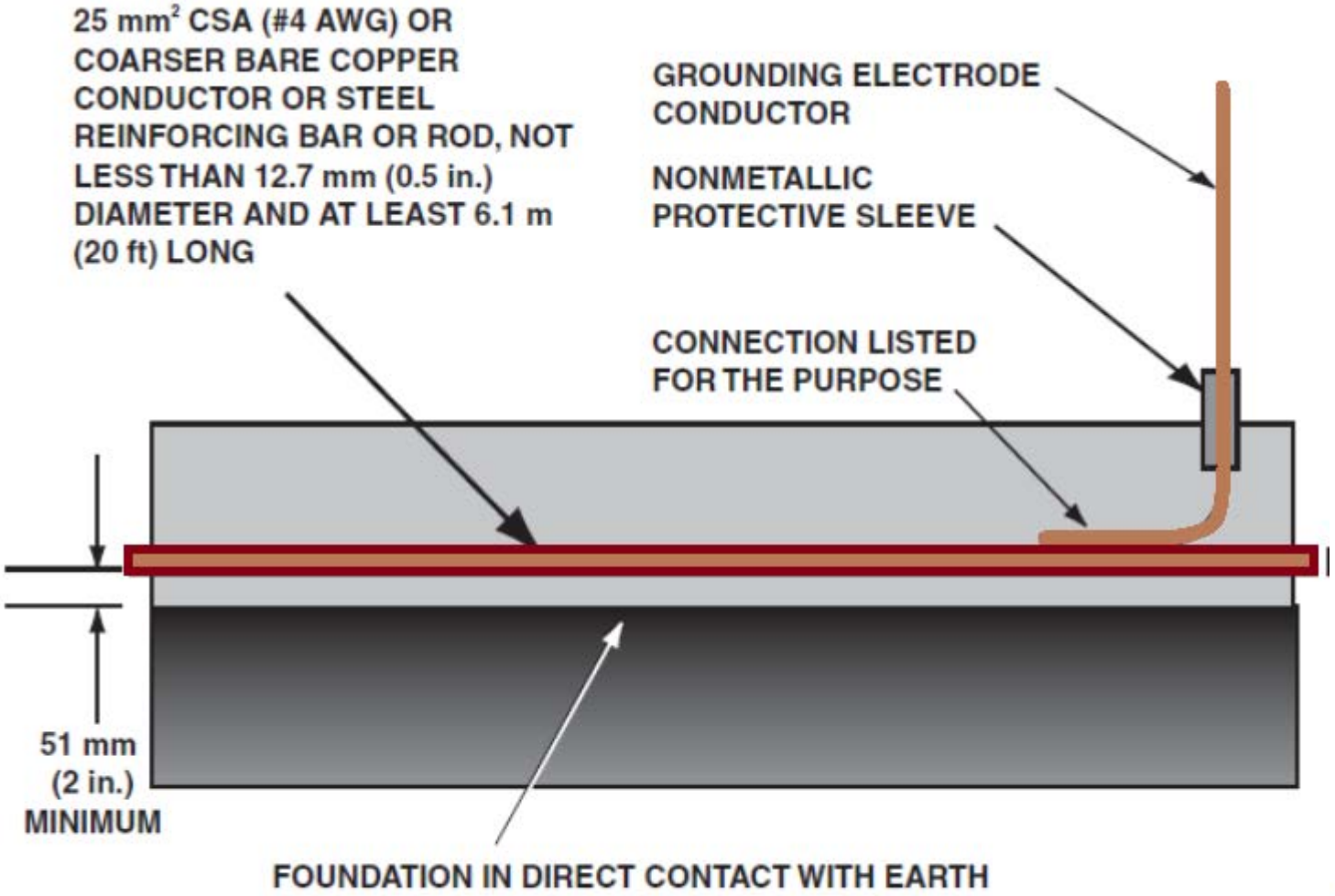
- Concrete-encased electrodes shall be encased by at least 51 mm (2 in.) of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth (or ground).

- It shall be at least 6.1 m (20 ft.) of bare copper conductor not smaller than 25 mm2 (#4 AWG) or at least 6.1 m (20 ft.) of one or more bare or zinc galvanized or other conductive coated steel reinforcing bars, or rods at least 12.7 mm (0.5 in.) in diameter.

- And, shall be bonded to any other grounding electrode system at the site as per NFPA 70-2017.

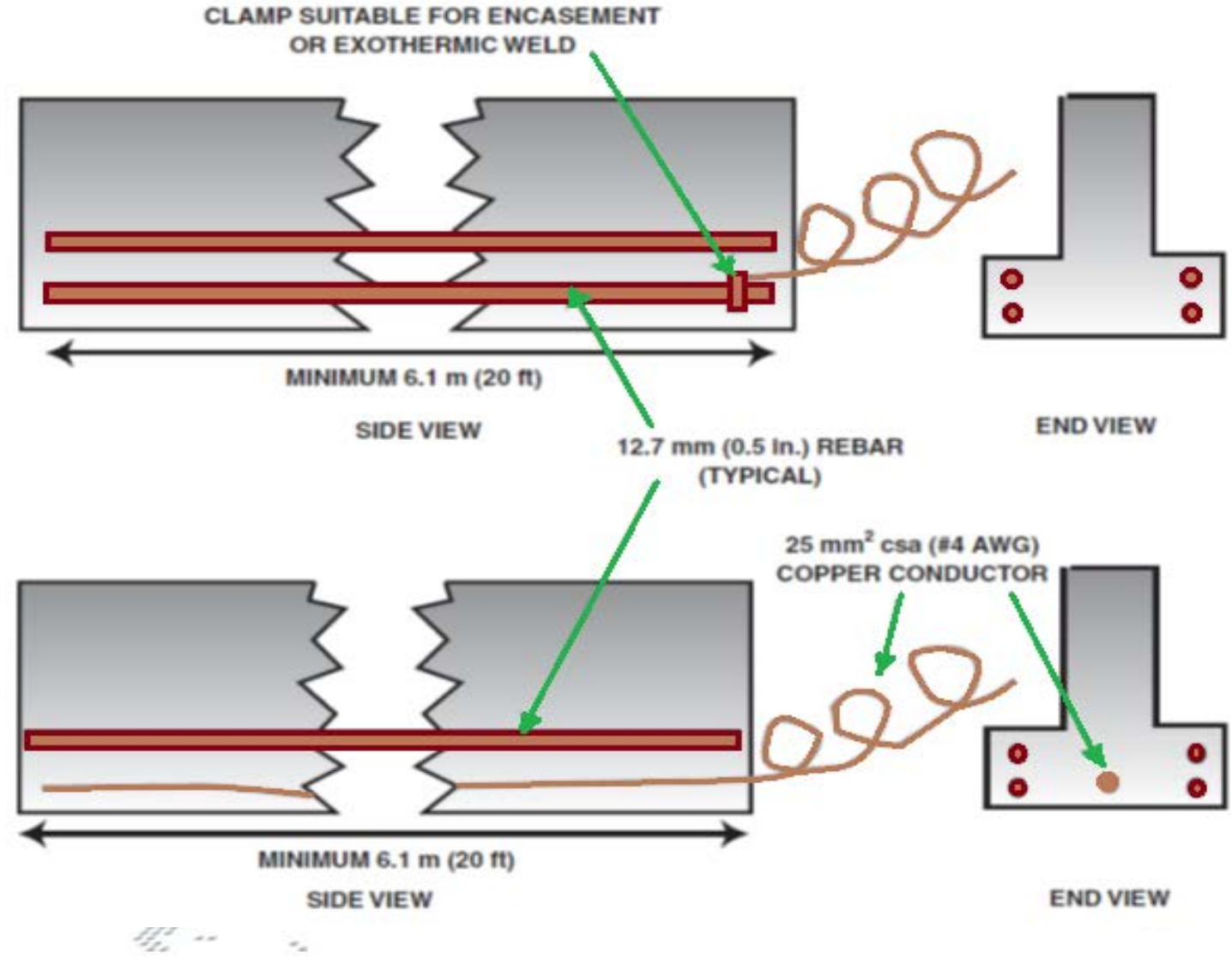
8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems



8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems



9. Reading References for Grounding & Bonding Specially on Areas with Poor Conductivity Soil Conditions

BS 7430:2011 (Code of Practice for Protective Earthing of Electrical Installations)

ISO/IEC 62305-3 (Protection of Structure Against Lightning)

IEEE 142:2007 (Green Book – Grounding of Industrial & Commercial Power Systems)

Motorola R56 (Standards & Guidelines for Communication Sites)

MIL-HDBK-419A (Military Handbook Grounding, Bonding & Shielding for Electronic Equipment & Facilities)

MIL-UFC-3-580-01:2016 (Military Unified Facility Command Telecommunications Interior Infrastructure Planning & Design)

MIL-I3A Standard 2010 (Military Technical Criteria for the Installation Information Infrastructure & Architecture)

UL – 469:2013 (Grounding & Bonding Equipment)

BICSI

10. Where to Buy Codes and Manuals mentioned

www.bicsi.org

www.iso.org

www.global.ihs.com

www.tiaonline.org

Thanks a lot

Anthony I Madroño

Contact: +63.899.4278 & 80

+63.917.540.0842

Email: tony.isicorp@gmail.com

Bicsi

(D) Installations Not Covered by NEC

- Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations

- Installations under the exclusive control of an electric utility where such installations

- a. Consist of service drops or service laterals, and associated metering, or

- b. Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, energy storage, or distribution of electric energy, or

- c. Are located in legally established easements or rights-of-way, or

- d. Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, energy storage, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the U.S. Department of the Interior Bureau of Indian Affairs, military bases, lands controlled by port authorities and state agencies and departments, and lands owned by railroads.

Highlights of the next edition of the National Electrical Safety Code

Beyond the Service Point

As the definitive safety standard for more than a century, the National Electrical Safety Code® (NESC®) continues to be the go-to standard for electric and telecom utility companies of all sizes and ownership of structures. Within the utility environment, the NESC is used by a myriad of users, including business leaders, operations management, engineering and line designers, crew supervisors, safety trainers, and others. The 2023 version, edited by the IEEE Standards Association (IEEE SA), will be published in August 2022 and will become effective on February 1, 2023.

by Nelson G. Bingel III, Chairman, NESC, and Dr. Lawrence M. Slavin, Contributor, NESC

Purpose and Format

Published exclusively by IEEE SA and typically updated every five* years to keep the Code current with changes in the industry and technology, the NESC sets the ground rules and guidelines for the practical *safeguarding of utility workers and the public* during the installation, operation, and maintenance of electric supply, communication lines, and associated equipment. (*This time around, the COVID-19 pandemic caused a delay in the typical release cycle)

Like previous versions, the 2023 edition will be available in digital, printed, e-Learnings, and mobile-app formats. The edition consists of initial sections covering scope, purpose, and grounding methods, followed by sections that include specific rules for electric supply stations, overhead lines, underground lines, and safety-related work practices.

A companion document, the 2023 NESC Handbook, will be published at the same time as the Code. The Handbook includes all of the rules of the code but also provides insights and commentary on the rules and how to apply them from the experts who helped develop the Code. The new handbook format will be more user-friendly, as the handbook text is interspersed with the code rules to include historical notes and provide context for revisions and additions. The previous edition of the handbook, the 2017 edition, is available in Spanish and Chinese, and the 2023 handbook will be translated in the near future.

2023 NESC Highlights

Revisions in the 2023 NESC are intended to provide clarity and ease of use, which ultimately point back to its purpose – safety. Goals of the revision process include modernizing and keeping the Code relevant, making it more intuitive and easier to understand, and accommodating the emergence of new technologies such as solar and wind energy, distributed energy/microgrids, battery technologies, energy storage, and wireless small cell networks.

Online e-Learning courses, originally introduced with the 2017 edition, will be updated to include the new changes on grounding methods, electric supply stations, overhead lines – clearances and strength & loading, underground lines, and work rules. The new courses will be available on August 1, 2022.

Before diving into some of the Code revisions, notable changes have been made to units of measurement intended to help prevent mistakes in applying the safety rules. All stand-alone tables for

metric measurements will be removed from the main code body and moved to Annex 1. For tables that include both English and metric values, the revised Code presents numerical values in the customary "inch-foot-pound" system first and the corresponding metric values following in parentheses. These and other changes were introduced to help prevent users from making serious errors caused by misreading a value as being metric when, in fact, they are U.S. values.

A few notable revisions to the Code include:

- In the Clearances section, as well as in the specification of the Grade of Construction in Table 242-1, the Code further clarifies the use of non-hazardous fiber optic cables as telecom providers continue to expand their networks.
- Revisions in the Strength & Loading sections include modified Rule 250C, which addresses extreme wind loading for overhead lines. Two wind maps are now provided instead of the previous single one. A map for Grade B, the highest grade of construction, with a Mean Recurrence Interval (MRI) of 100 years (corresponding to a one percent annual probability of occurrence) is provided in place of the previous 50–90-year MRI map. For Grade C construction, a separate 50-year MRI (two percent annual probability of occurrence) map is now provided. In the previous Code, a factor was applied to the 50–90-year MRI map for application to Grade C. Changes were also made to the method of determining the corresponding wind loads, consistent with the latest engineering practices.
- As an example of a Code revision focused on public safety, the ground end of *all* anchor guys adjacent to regularly traveled pedestrian thoroughfares, such as sidewalks, and similar places where people can be found must include a substantial and conspicuous marker to help prevent accidents. The previous Code did not require the marking of every such anchor guy.

Addressing Recent and Emerging Technologies

Just as it has done for more than a century, the NESC is continuously evolving and being refined to embrace new technologies. Today, this includes emerging technologies such as solar and wind energy, distributed energy/microgrids, batteries and energy storage, and wireless small cell networks – while addressing both the opportunities and any safety issues they present. The potential impacts of recent and emerging technologies are reflected in the new Code, including the following:

- Significant revisions were made in Section 14 covering batteries. Previous editions of the code were based on lead-acid technology and batteries only used for backup power. The 2023 Code incorporates the new battery technologies and addresses energy storage and backup power.
- A new Section 19 of the code covers photovoltaic generating stations, with sections addressing general codes, location, grounding configurations, vegetation management, DC overcurrent protection, and DC conductors. These new rules accommodate large-scale solar power projects.
- In the Clearances section, all rules for wireless antenna structures have been consolidated in the equipment section (Rule 238 and 239), which makes the Code more user-friendly.

To further address new technologies in subsequent editions of the Code:

- A new subcommittee was created focusing on generating stations, with the original subcommittee continuing to address substations.
- A working group is investigating Fault Managed Power Systems (FMPS) cables as the technology may be used for 5G networks. The team is looking at possible impacts, including clearances and work rules.

These are just a few of the highlights of the 2023 NESC, which is the product of hundreds of contributors and peer reviewers and the careful editing of the IEEE Standards Association. For more information, please visit standards.ieee.org to learn more information about the NESC and NESC Products. We welcome you to join our efforts by joining the NESC!

Abandoned Cable Review

NEC 2020 - Definitions

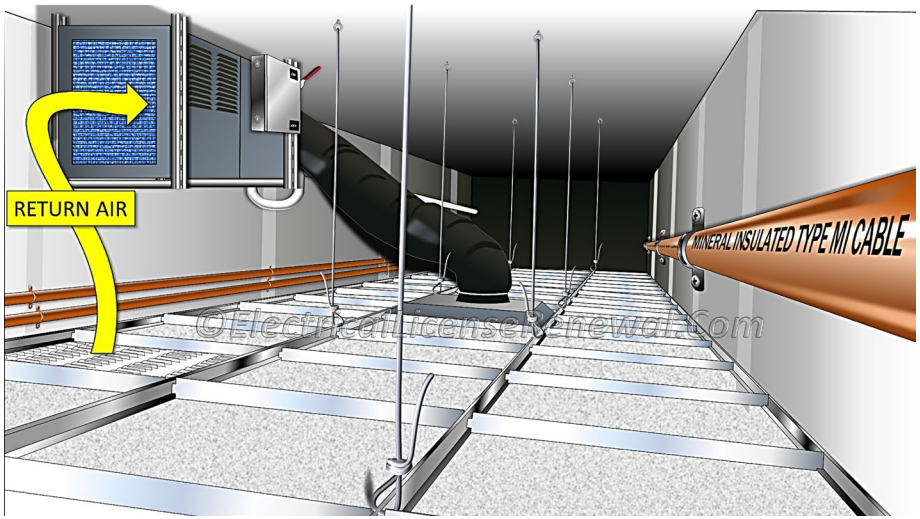
Articles 640
Articles 645
Articles 725
Articles 760
Articles 770
Articles 800

NFPA-90A
NFPA-75
NFPA-76

Abandoned Cable & Plenums

What is a Plenum ?

- Article 100 – Definitions - pg 70-39
- Section 800.113 (C) - pg.70-668



Abandoned Cable & Plenums

- Understand the background of abandoned cable issue ie "Fuel Load"
- Understand NEC Code requirements governing the removal of abandoned cables
- Understand relative fire safety performance of available network cabling products

Why is it important to consider the fire safety performance of network cable?

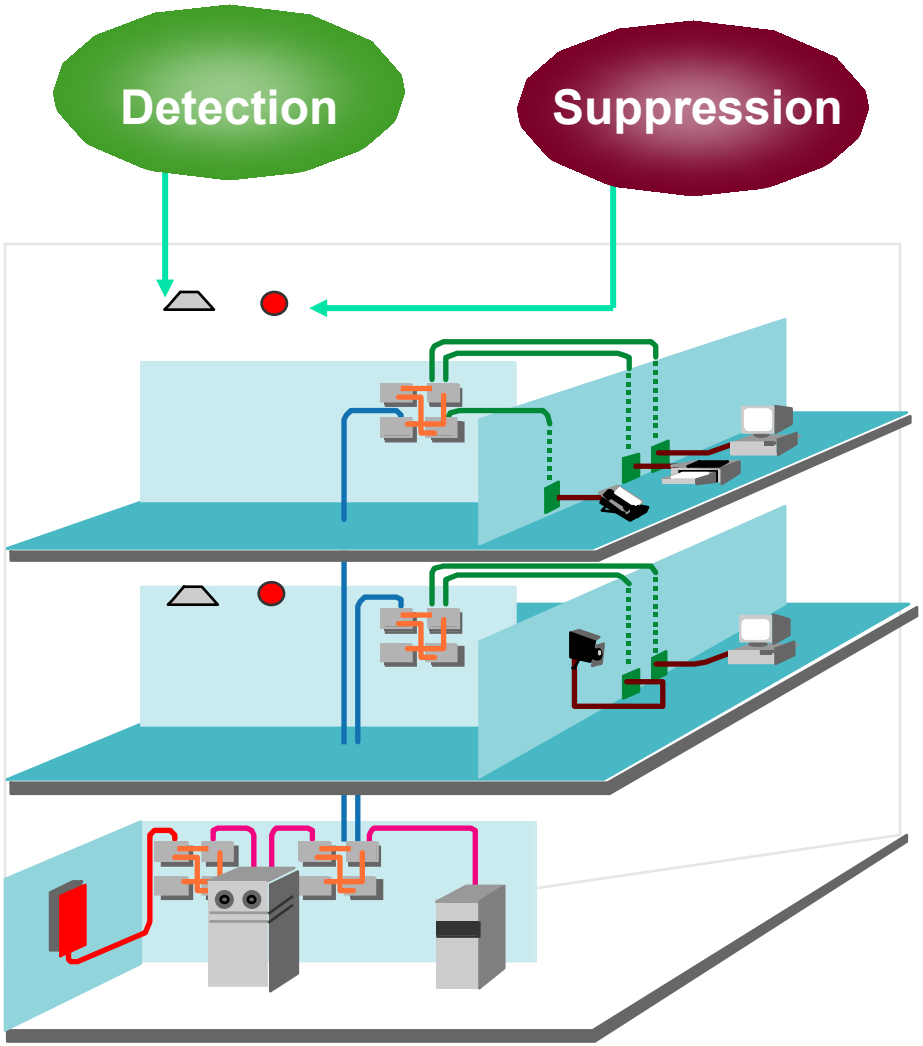
- A small fire caused by electrical failure can ignite cables
- Certain cables burning generate large amounts of thick black smoke which can hamper evacuation.
- Cables can provide fuel to a fire allowing the fire to spread rapidly through concealed spaces.
- Smoke generated by burning cables is particularly damaging to electronics

Fire Investigations: Lessons Learned

- Ignition source is often electrical failure
- Cables can add significant fuel load and spread fire rapidly
- Mechanism of fires spread by following cable pathways and spaces
- Small fires can cause extensive smoke damage
- Combustible materials in concealed spaces are of great concern.

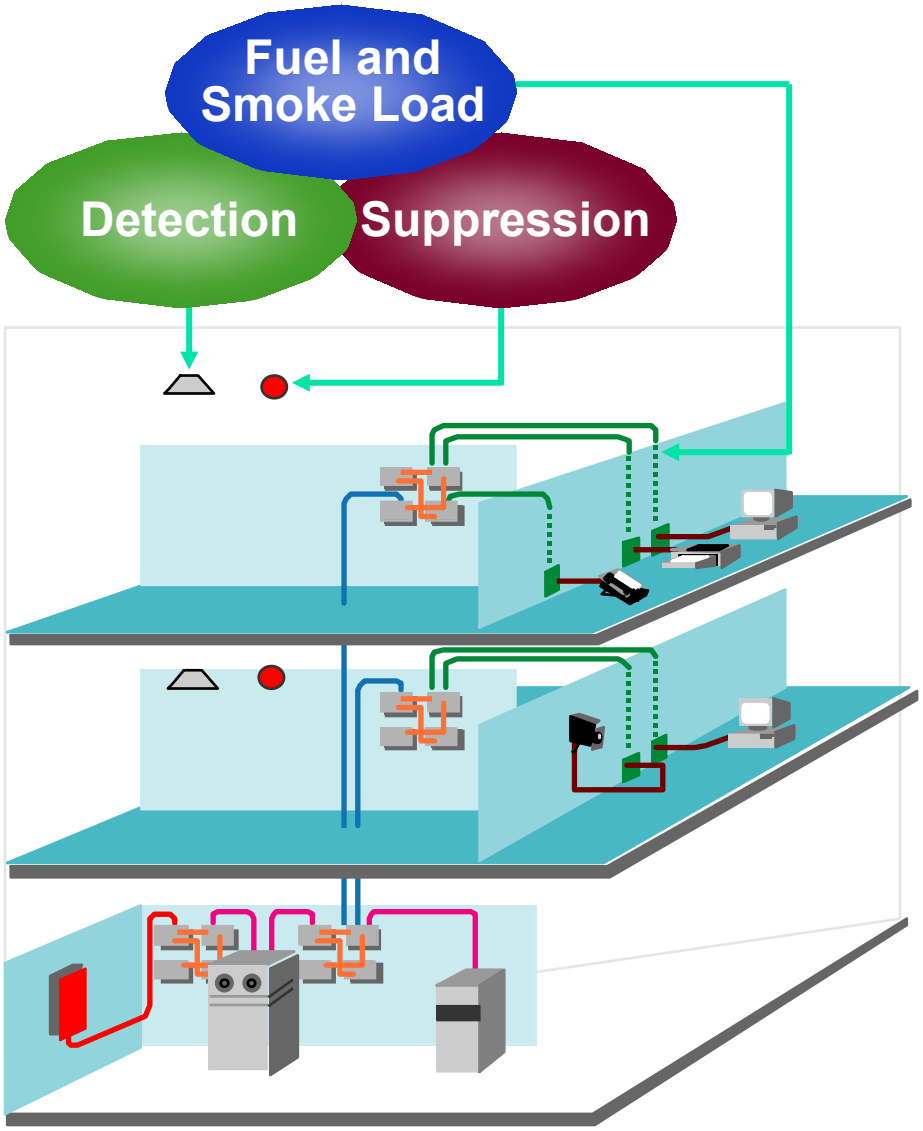
Investments in building safety

- To prevent or minimize the effects that a fire will have on their business, companies should invest in safety measures to protect their people, facilities, and equipment.
  - Passive and active systems
  - Evacuation procedures and drills
  - Safe practices
  - Contingency and disaster recovery plans



Reducing the hidden hazard from communications cabling should be a part of our investment in protecting people, facilities, and equipment. Removal of abandoned cable from plenums is one key step.

Fuel Load & Smoke



Abandoned Cable Makes Headlines

Buildings

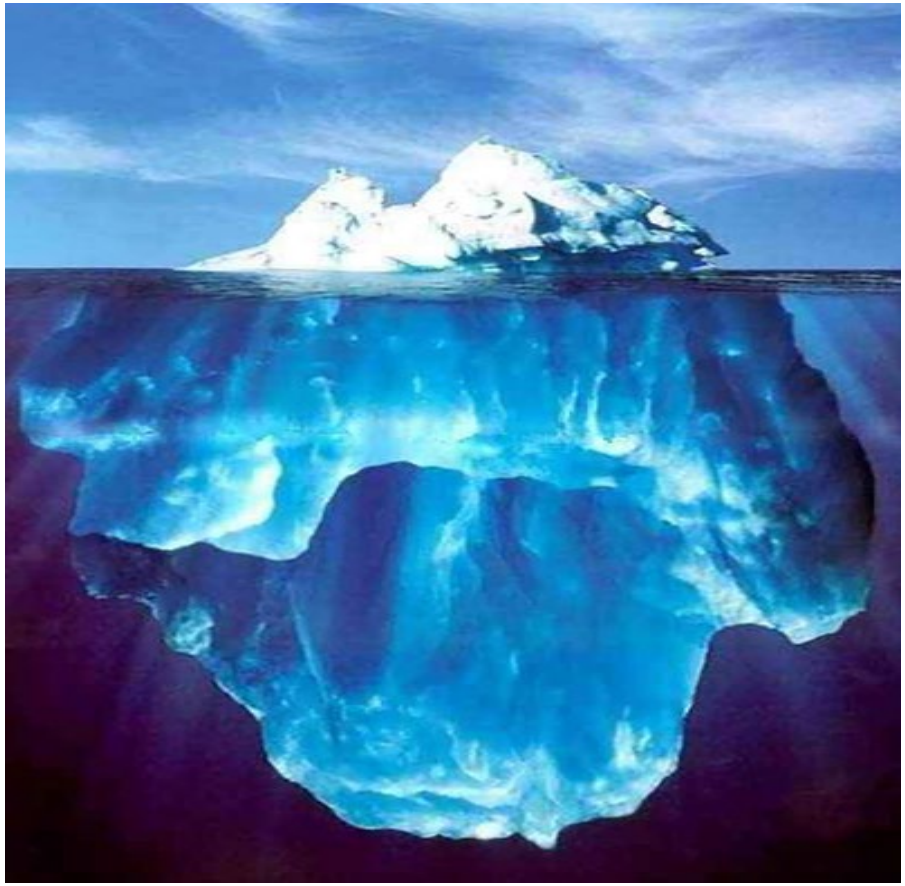
Wired in to NEC Changes?
Ensure Your Facilities Are Code-compliant

National Real Estate Investor
Abandoned Cable Issue Could Trip Up Owners

Atlanta Business Chronicle
Abandoned cable is fire hazard; removal onerous

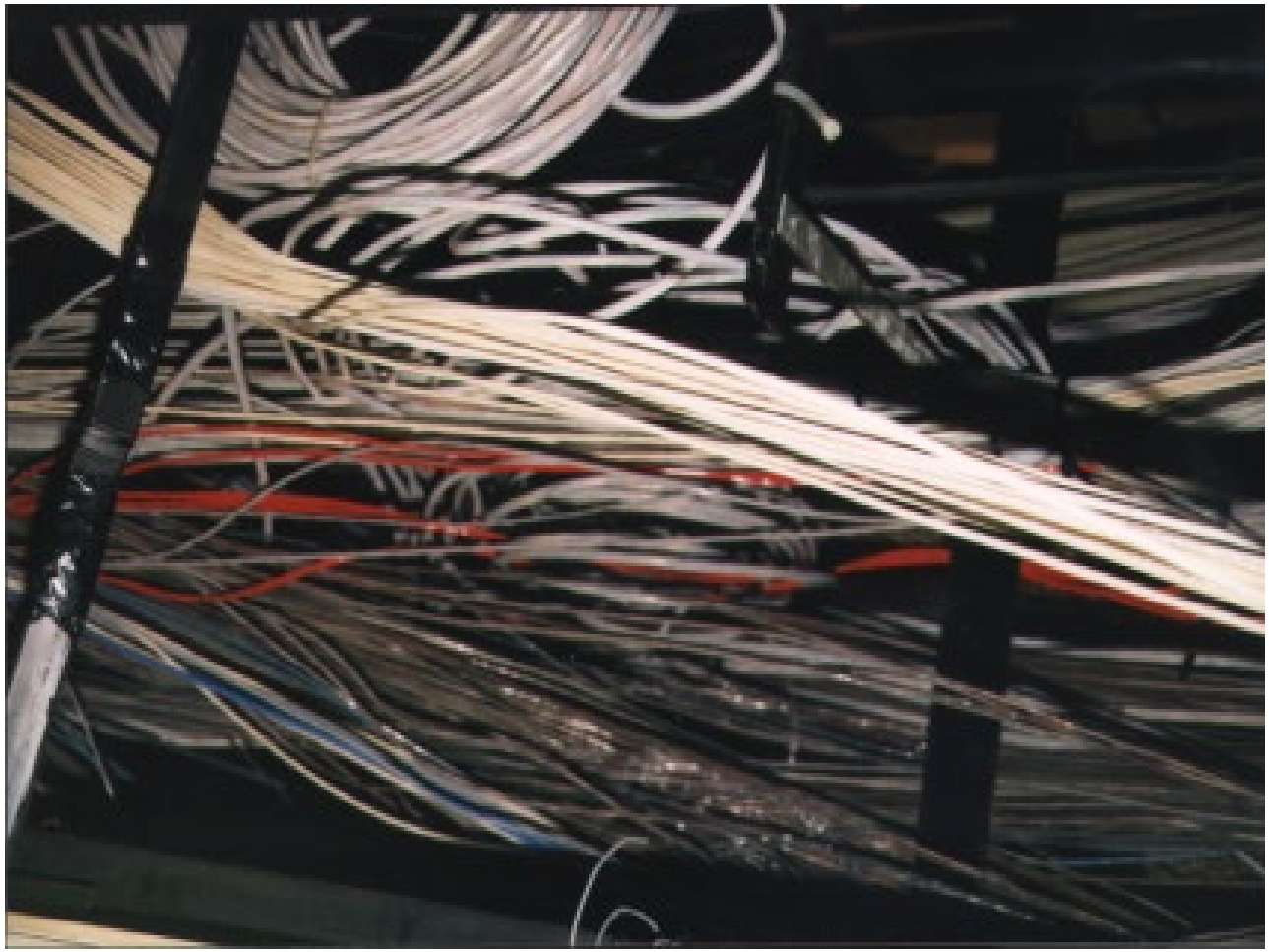
The New York Times
Landlords and Tenants Wrestle With Wiring

What lurks beneath?

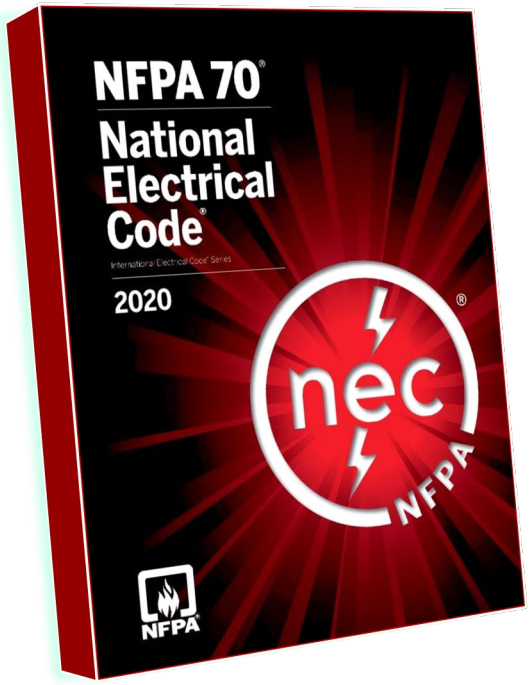


Or – in our case -- What lurks above?

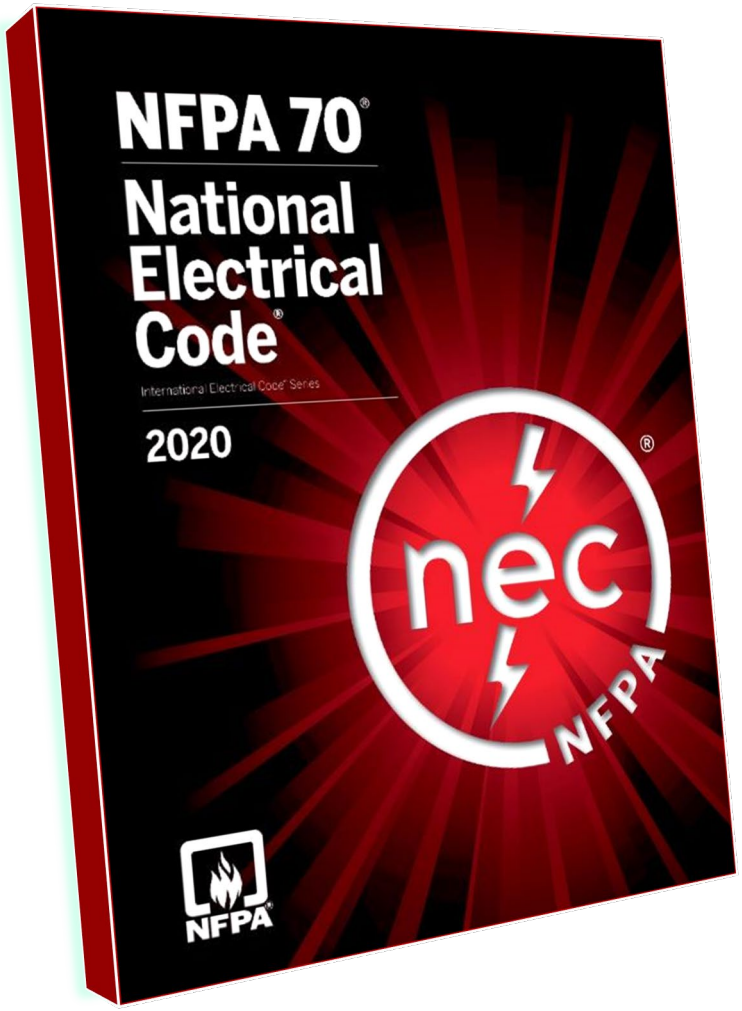
Hidden Hazards - Above ?



NFPA codes and standards represent a set of minimum fire safety requirements for the protection of buildings.



NFPA 70 is responsible for plenum cable products and applications.



- NFPA 70 – National Electrical Code (NEC):
  - Recognizes hazards associated with cables in plenums
  - Requires removal of abandoned cable from plenums
  - Fine Print Note (FPN) points to NFPA 13 requirements for plenum sprinklers where there is combustible loading

National Electric Code Fire Safety Hierarchy for Copper Communications Cable

Cable Type	Insulation	Jacket
CMP - Plenum	FEP	LS-PVC*
CMR - Riser	PE	FR-PVC*
CM – General Purpose Communication	PE	PVC*

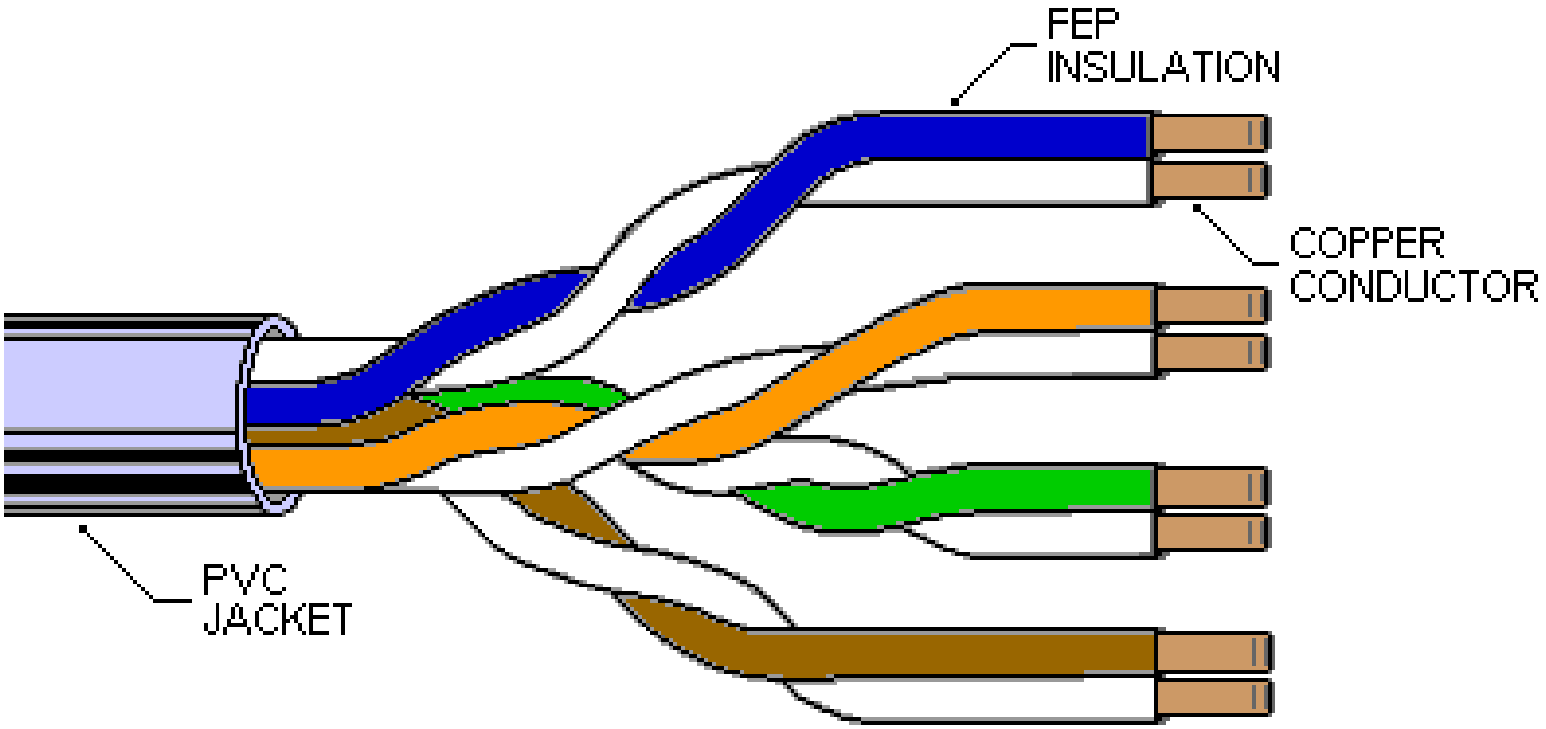
*Different PVC compounds

National Electric Code Fire Safety Hierarchy for Copper Communications Cable

Cable Type	Insulation	Jacket
LCC – Limited Combustible FHC 25/50 CMP	FEP	FEP or FP Compound
CMP - Plenum	FEP	LS-PVC*
CMR - Riser	PE	FR-PVC*
CM – General Purpose Communication	PE	PVC*

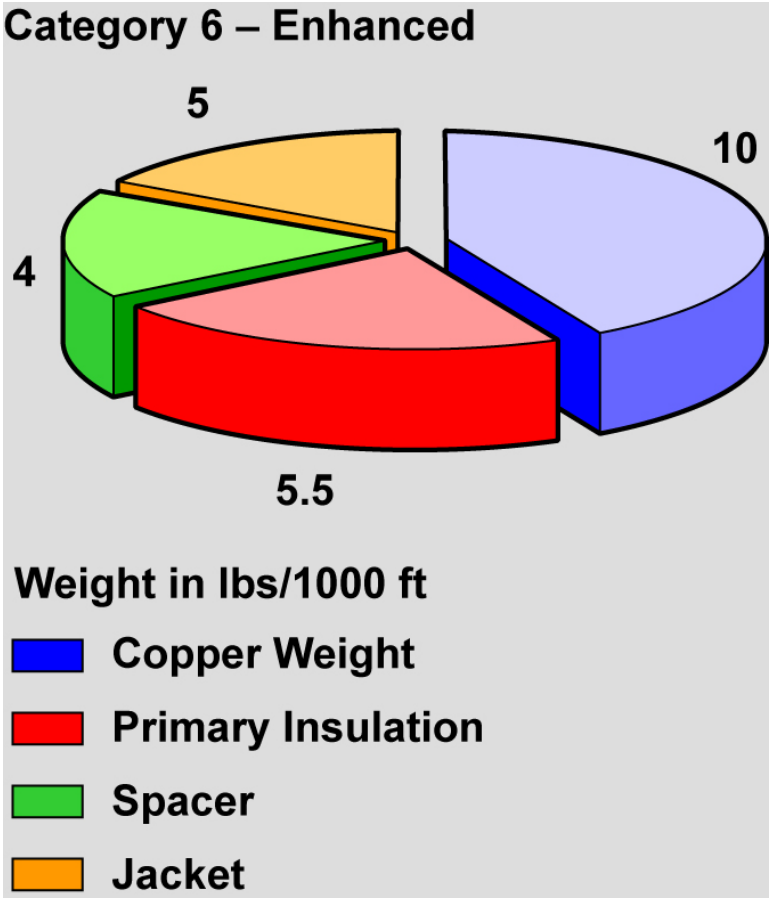
*PVC compounds containing different levels of flame retardant and smoke inhibitors

What is Plenum Cable?



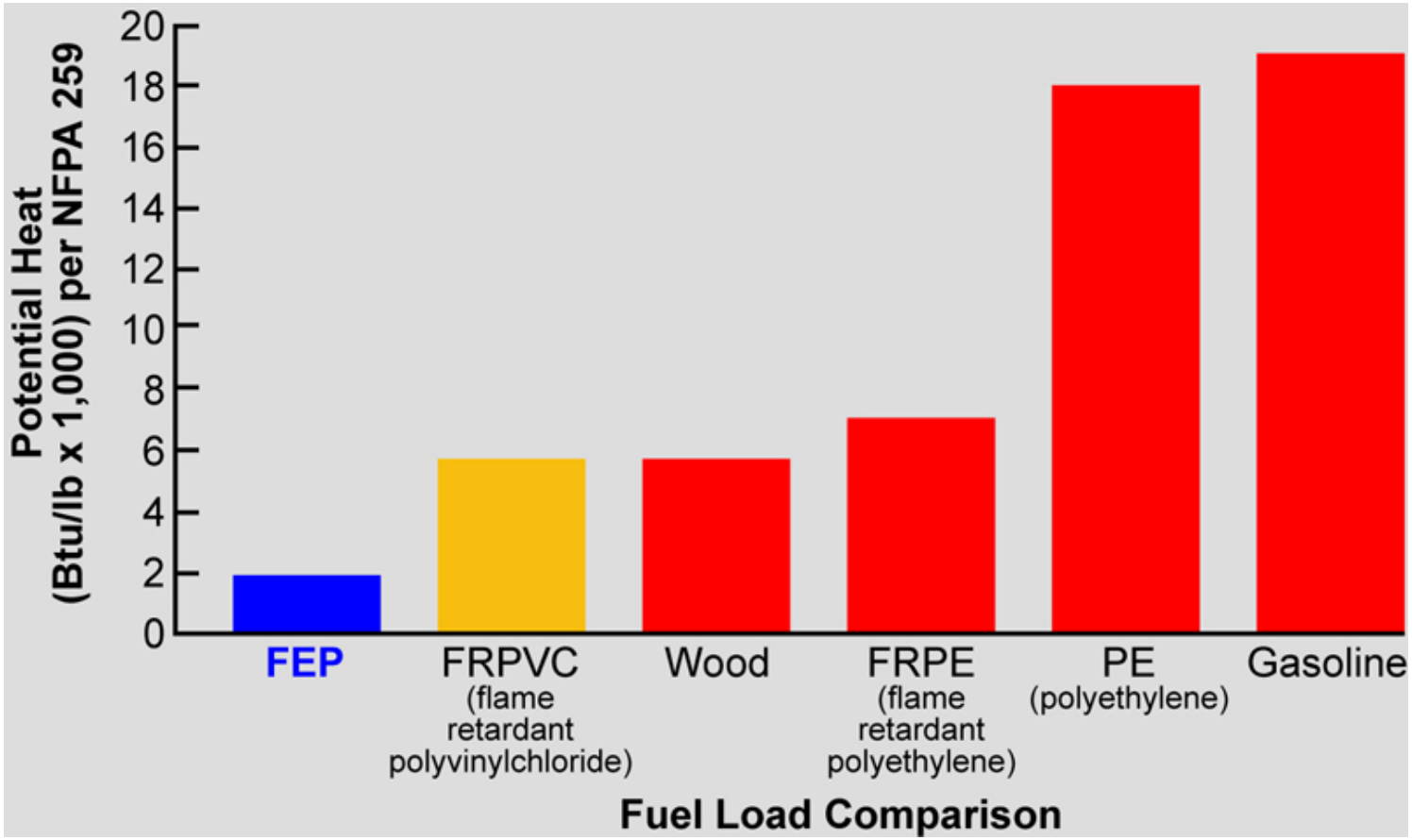
4-Pair UTP Plenum Rated Cable (CMP)

Typical composition of 4-pair UTP Cables



- Composed of >50% plastics by weight
- Represents 1,500 lbs of potentially combustible material for every 100,000 feet of installed cable

Insulation and jacket materials have a significant impact on the level of fire safety performance



Burning Characteristics of Communications Cables

Cable Fire Research

CMR

CMP

LCC

DUPONT The miracles of science

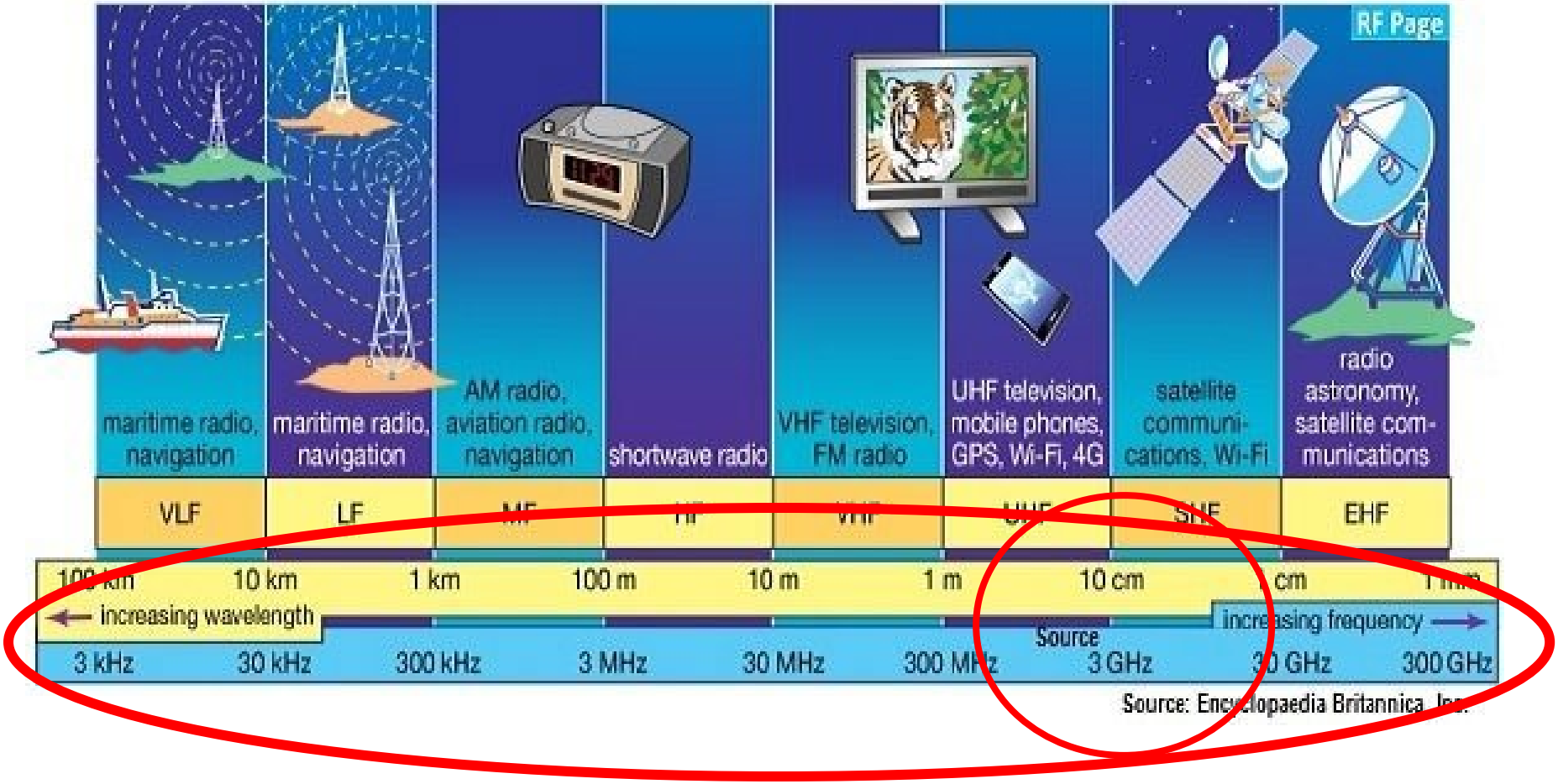
Environmental Concerns

- U.S. Green Building Council (USGBC)
  - LEED
- California
  - Proposition 65 (Lead)
- European Directives
  - Restriction of Hazardous Substances (RoHS)
  - Waste Electrical and Electronic Equipment (WEEE)

Increasing attention is being paid to the impact of electrical and electronic wastes, including cable

- **Which cables offer greater environmental sustainability?**
- Should not contain any substances or components regulated under the RoHS and WEEE Directives.
- Be Free of heavy metals (lead) and phthalates.
- Be Free of hazardous substances such as PBB and PBDE.
- Comply with California Proposition 65 (requires no warning labels on product).
- Offer more complete recyclability of both copper and plastics at end-of-life.
- Contain post-industrial recycled content today, with options for post-consumer content in the future.

Wireless & Radio Frequency Bands (RF)



300MHZ – 30GHZ

WiFi - Technology

Radio Frequency (RF) Transmission

Public Band – 2.4GHZ & 5GHZ - Competition

- Cordless Phones
- Microwaves
- Radio controlled toys
- Access devices
- Wireless LANS (WLANS)

WiFi - Technology

Radio Frequency (RF) Transmission

"Wi-Fi" radios

- Efficient encoding techniques
- Allow "frequency hopping"
- Powered devices (repeaters) can be inserted into the system.

WiFi- Standards

- IEEE 802.11 a,b,g.
  "Wi-Fi" Certified (1991-2003)

- IEEE 802.16 & IEEE 802.16a
  "WiMAX" MAN Networks
- Bluetooth
- HomeRF
- RFID
- IEEE 802.1X - security

First Gen - IEEE/WiFi Standards

IEEE 802.11

Speed – 2Mbps
Band – 2.4GHZ

Comments
Extended to 802.11b

IEEE 802.11b

Speed – Up to 11Mbps
Band – 2.4GHZ

Comments
“Wi-Fi” Certified
14 Channels (11 US)
Not interoperable with 802.11a
Susceptible to RF interference

First Gen - IEEE/WiFi Standards

IEEE 802.11g

Speed – Up to 54Mbps

Band – 2.4GHZ

Comments

“Wi-Fi” Certified

14 Channels (11 US)

Improved security over 802.b

Susceptible to RF interference

IEEE 802.11a

Speed – Up to 54Mbps

Band – 5GHZ

Comments

“Wi-Fi” Certified

8 Channels

Less susceptible to RF

More susceptible to obstructions

Better for high bandwidth APPS - video

Long range “drop-outs”

Other Notable IEEE Standards

IEEE 802.16

IEEE 802.16a

Speed – Up to 54Mbps

Band – 10 to 66GHZ (802.16)
2 to 11GHZ (802.16a)

Comments

"WiMAX"

MAN networking

Security and compatibility with WLAN products an issue

Bluetooth

Speed – Up to 2.4Mbps

Band – 2.4GHZ

Comments

No IP support yet

Short distances – 10 meters

Susceptible to RF

More - Standards

HomeRF

Speed – Up to 10Mbps

Band – 2.4GHZ

Comments

No longer support

Some legacy equipment exists

RFID

Multiple Bands

125KHz- animal tags

915MHz(UHF) - logistics

2.4GHZ – ISM apps for Active devices (transponders)

Comments

Auto-ID segment

Needs cables for antennas and data collection devices

Next Generation of Standards

Generation of network connection	Sample user interface visual
Wi-Fi 6 (802.11ax)	
Wi-Fi 5 (802.11ac)	
Wi-Fi 4 (802.11n)	

IEEE

Wi Fi ALLIANCE

Next Generation of IEEE Standards

802.11n (Wi-Fi 4) - *2009*

- Speed – Up to 600Mbps
- Bands – 2.4GHZ
- Interim between 802.11g and 802.11ac
- Introduced MIMO

802.11ac- (WiFi-5) – *2014*

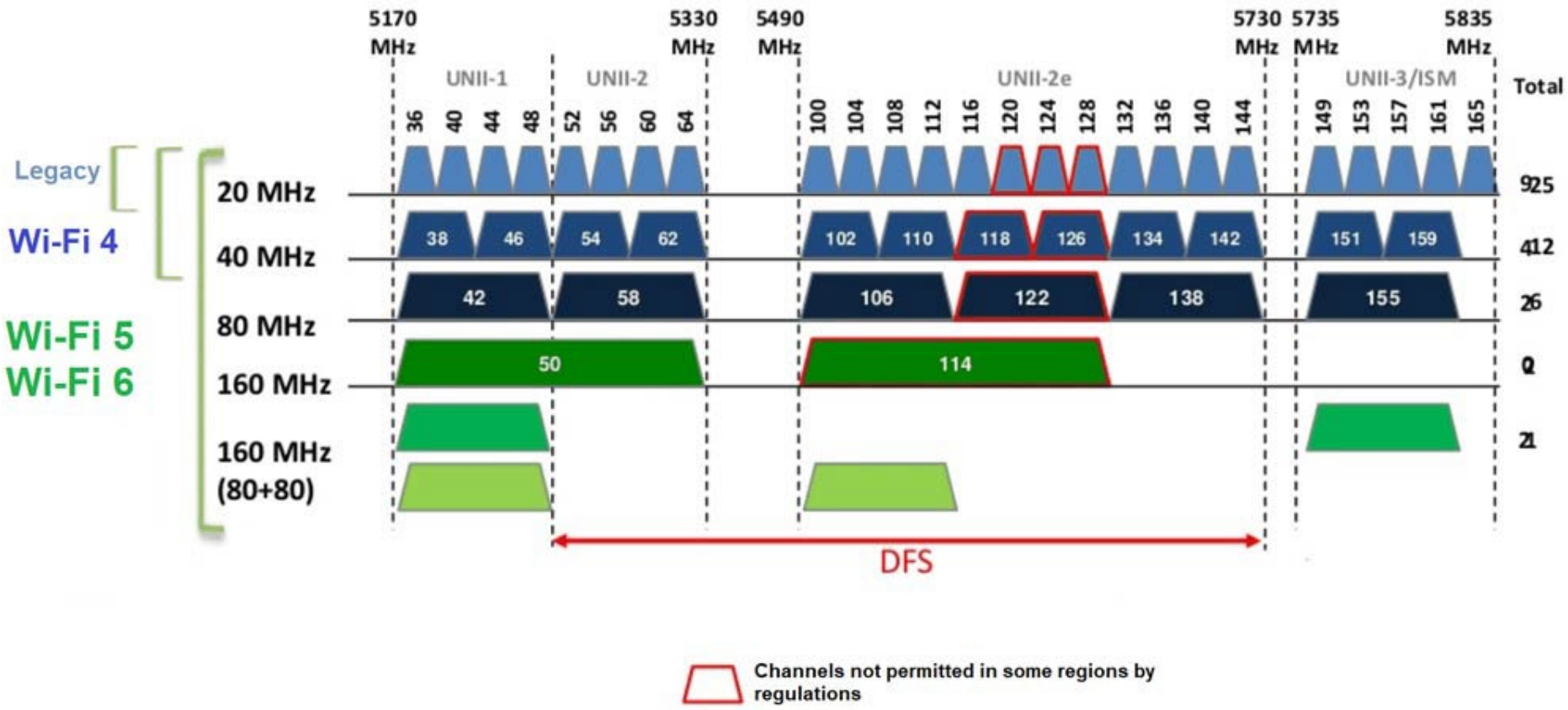
- Speed – Up to 1,300 on 5GHZ & 450 on 2.4 GZ
- Dual Bands – 2.4GHZ & 5GHZ
- Backward compatible
- Introduced MU-MIMO – 4 devices simultaneously
- Being replaced by 802.11ax

Next Generation of Standards

802.11ax (WiFi-6)- *2019*

- **Speed – Up to 10G**
- **Dual Bands – 2.4GHZ & 5GHZ**
- **Backward compatible**
- **Multiple Channels**
- **MU-MIMO – Devices communicate simultaneously**
- **OFDMA - data to multiple devices**
- **POE +(30-watts)**
- **Cable recommendation is (2) two- Cat6/Cat6A**
- **Devices & Adoption rates**

The 5GHz band's Wi-Fi channels



FCC Opened the 6GHZ band to the public

802.11ax (WiFi-6E)- *2020*

"In layman's terms, if the 2.4GHz band is a one-lane country highway and the 5GHz band is a three-lane interstate, picture the 6GHz band as a shiny, new seven-lane superhighway, and only 6E devices get access to the onramp." *

- Not a new protocol but expands on WiFi 6 by adding more bandwidth
- Compatibility
- Devices coming to market now

Implementation Challenges

Still in the public band 2.4GHZ

Range vs Speed

Speed decreases as distance increases

Ex: 802.11a at 100' was 12Mbps

802.11b at 100' was 1Mbps

To maintain higher through puts more access points are needed. = More Cabling

Security – encryption methods ($$$)

Implementation Challenges

WAP – Dual Bands - saturation

WAP – increase power- bleeding

Network performance – more users fighting for bandwidth

Changing Standards (802.11n)

Cable "Enabler"

Standards

TIA TSB-162 (Draft3.1)

Grid approach

TO every 250 to 360 sq/ft (60' grid)

Estimated cable increase 5-7%

Less testing than ISO

Standards

ISO/IEC 247-004

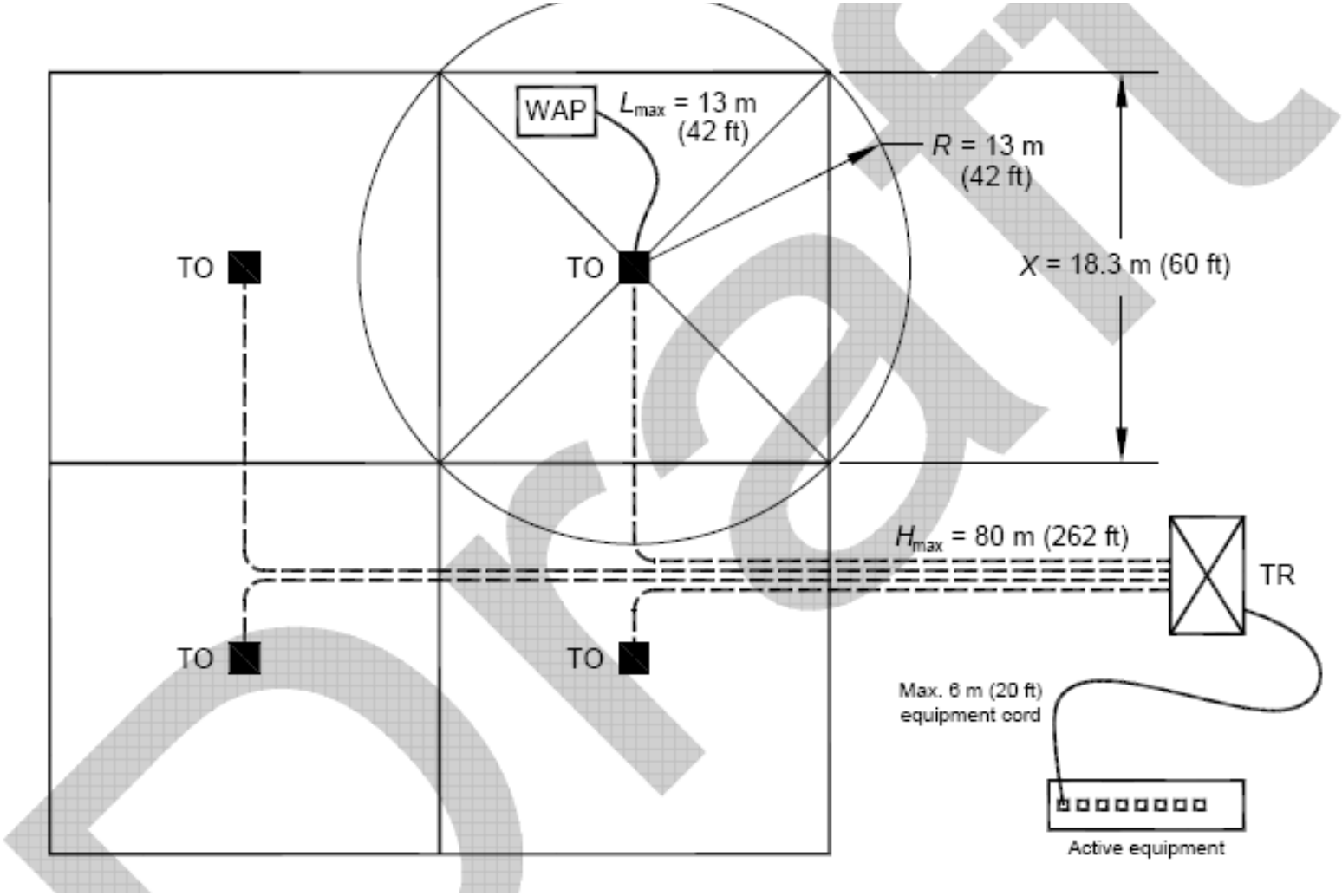
"Honey Comb" approach

TO every 12meters

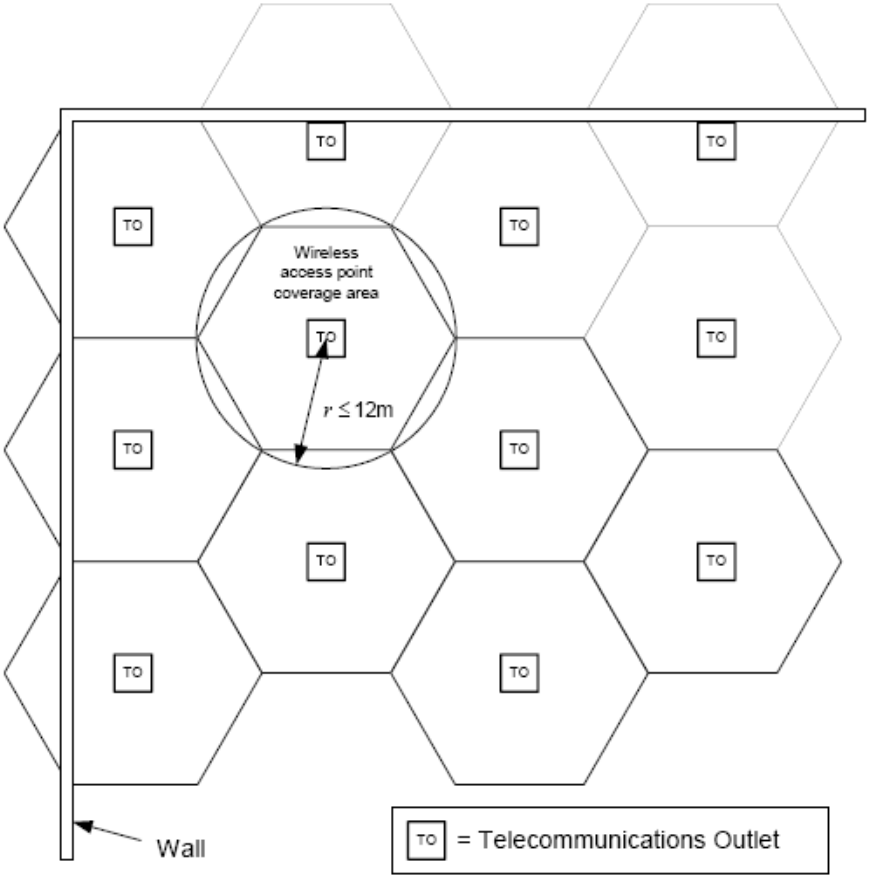
Estimated cable increase 5%

Pre-testing and post-testing highly recommended

Cable “Enabler” TSB-162



Cable “Enabler” ISO/IEC 24704-2016



NOTE 1 A "Honeycomb" grid provides the most efficient coverage. Other grid shapes such as squares or rectangles may be used.

NOTE 2 Under normal circumstances, the optimum mounting location for a wireless access point or antenna is at the centre of the cell.

Figure 1 – Grid of telecommunications outlets for wireless coverage areas

Distributed Antenna Systems (DAS)

Active Das

Passive DAS

Micro Cells (eRAN)

Tunxis Community College

Education That Works For A Lifetime

Understanding Cellular Coverage

- **Cell phone signals are Radio Waves.** Like AM/FM they operate in a certain frequency /wavelength. They require a Transmitter and a Receiver.
- **Decibel-milliwatts** or **dBm** measures the strength of the wave and are expressed in negative numbers. (-65 dBm) The closer to "0" the stronger the wave.
- **RSRQ** – The "Quality" of the cell signal received by the device.

Signal Strength	General Results
-50 to -79 dBm	Considered **great signal** (4 to 5 bars)
-80 to -89 dBm	Considered **good signal** (3 to 4 bars)
-90 to -99 dBm	Considered **average signal** (2 to 3 bars)
-100 to -109 dBm	Considered **poor signal** (1 to 2 bars)
-110 to -120 dBm	Considered **very poor signal** (0 to 1 bar)

Measuring Signal Strength -RSRQ

		RSRP (dBm)	RSRQ (dB)	SINR (dB)
RF Conditions	Excellent	>=-80	>= -10	>=20
	Good	-80 to -90	-10 to -15	13 to 20
	Mid Cell	-90 to 100	-15 to -20	0 to 13
	Cell Edge	<=-100	<-20	<=0

What Causes Poor Cell Reception?

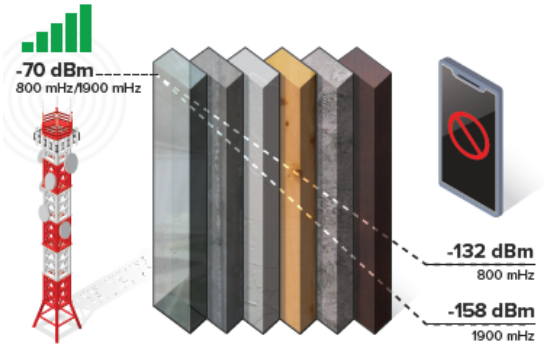
Physical Obstruction - Natural or man-made obstacles located between a phone and the nearest cell phone tower can also have a significant impact on overall signal strength. Common obstructions include:

Geographic Barriers - When a phone or cellular device isn't near a cell tower, signal can be weak or even undetectable. This is common when living or working in remote or rural areas faraway from cell towers.

Vegetation
Trees, shrubbery, and other kinds of foliage can absorb and weaken cell signals.

Man-made Objects
In urban settings, buildings obstruct cell signal that can't easily penetrate metal, brick, concrete, energy-efficient glass, and foam insulation. While inside cell reception can be spotty, you can also experience poor connectivity outside when surrounded by tall buildings.

Typical Building Scenario



Signal Amount Blocked

Material	800 mHz	1900 mHz
Low-E Glass Window	▼ 34 dB	▼ 34 dB
6" Concrete Wall	▼ 10 dB	▼ 19 dB
1/2" Drywall	▼ 2 dB	▼ 2 dB
Solid Pine 1/2"	▼ 2 dB	▼ 5 dB
Venetian Plaster	▼ 8 dB	▼ 16 dB
Solid Wood Door	▼ 6 dB	▼ 12 dB
TOTAL BLOCKED	**▼ 62 dB**	**▼ 88 dB**

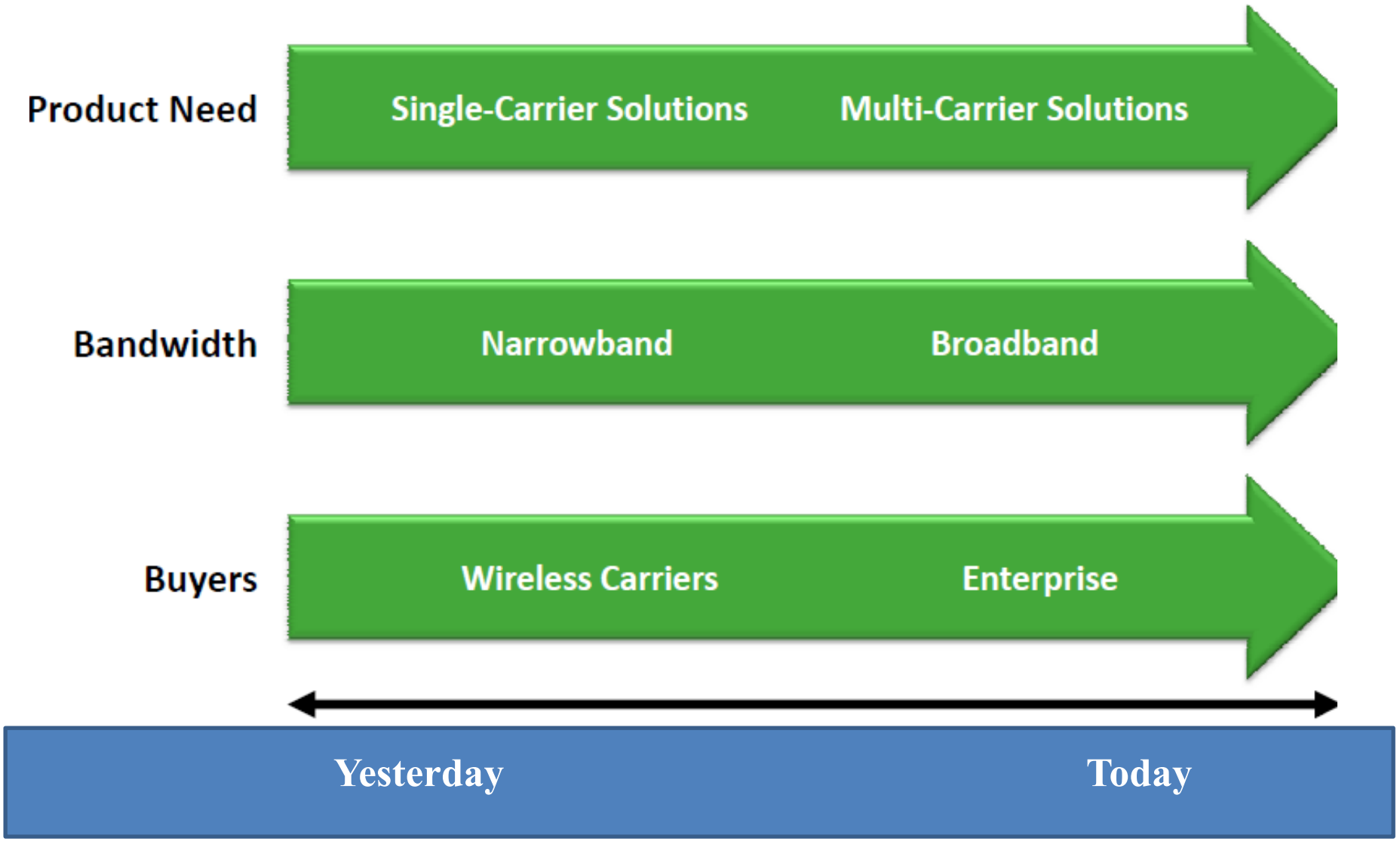
Distributed Antenna Systems

First, what is a DAS?

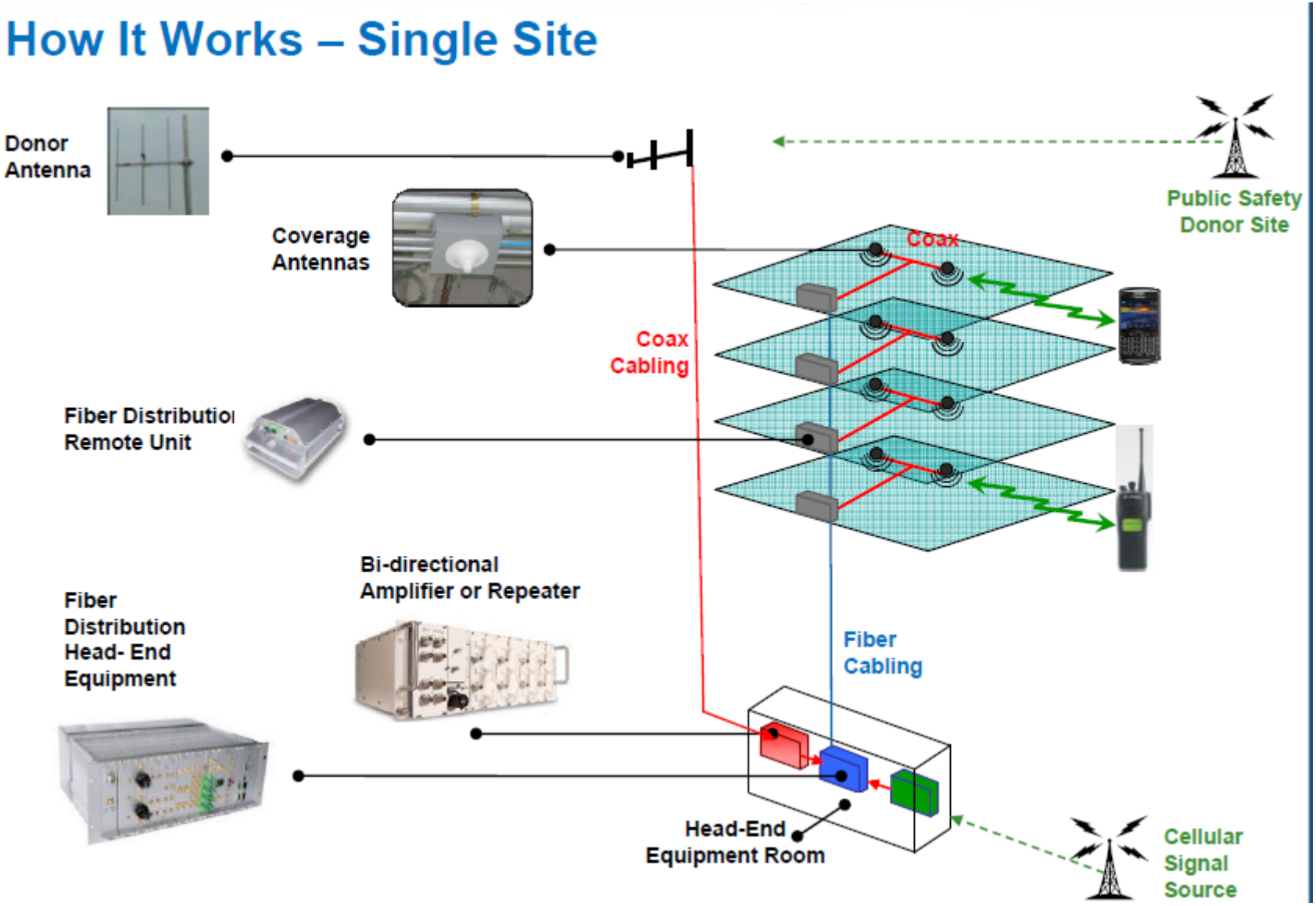
A ***Distributed Antenna System*** or DAS, is a network of spatially separated antennas connected to a transport medium – typically coax or fiber-optic cable -- that provides wireless service within a building or structure.

The DAS can be driven by a direct connection to a radio base station or an “off-air” repeater/signal booster.

Distributed Antenna Systems

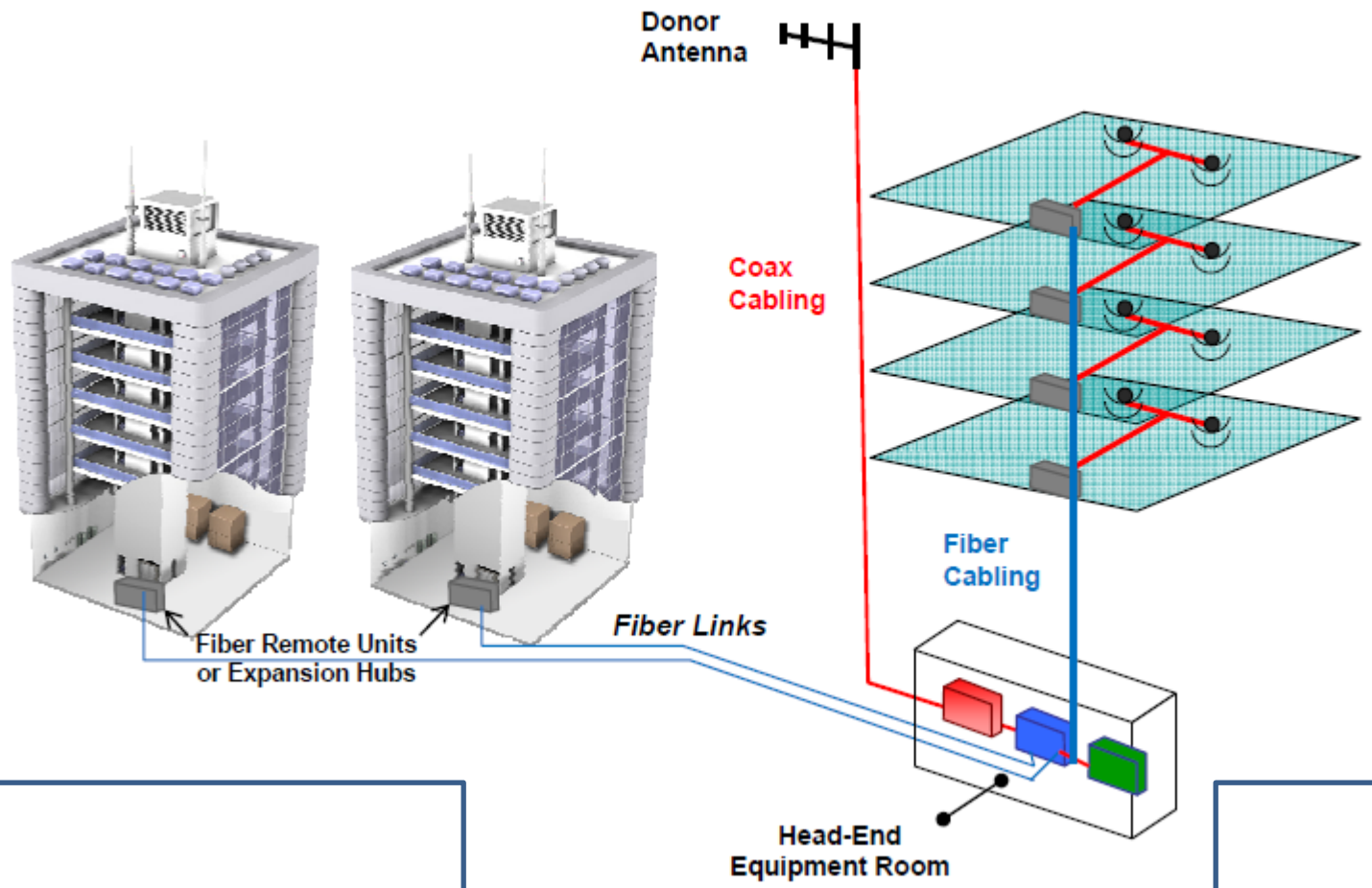


Distributed Antenna Systems



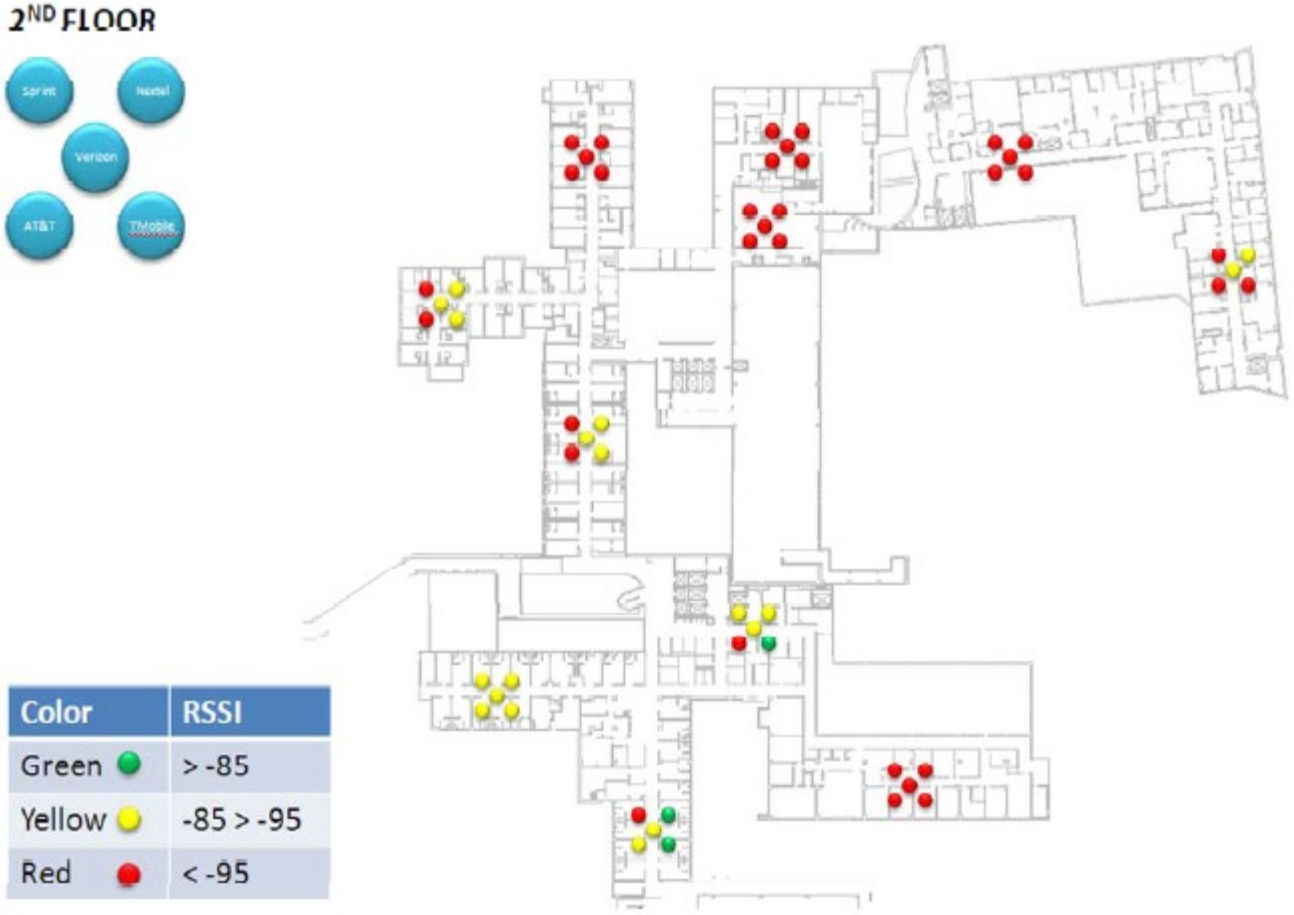
Distributed Antenna Systems

DAS in multi-site or Campus setting



Distributed Antenna Systems

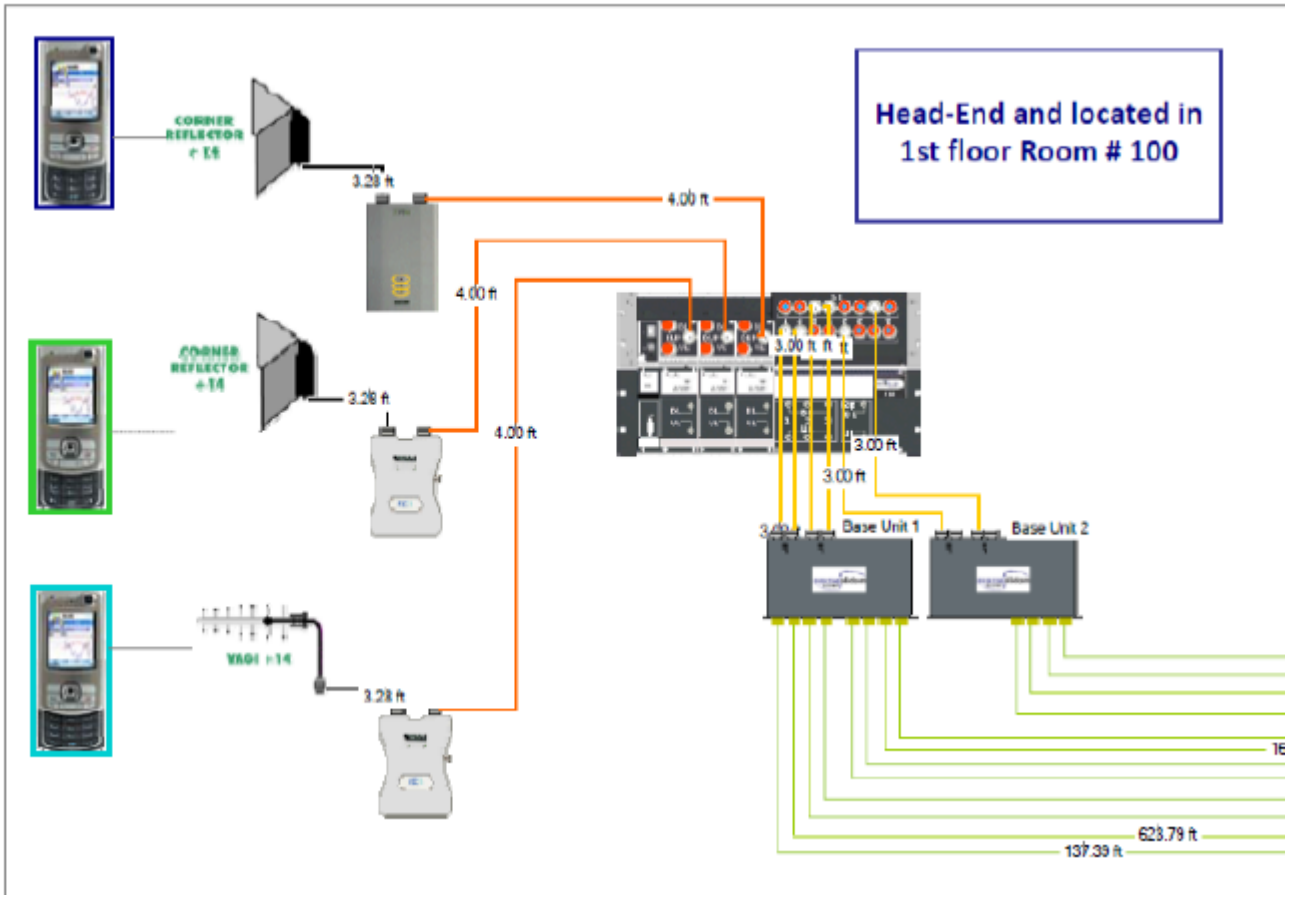
Coverage Needs Analysis



Color	RSSI
Green	> -85
Yellow	-85 > -95
Red	< -95

Distributed Antenna Systems

Design



Distributed Antenna Systems

Design: Typical Frequency Bands & Technologies

- AT&T: 850/1900 MHz GSM and UMTS/WCDMA
- Verizon: 700/850/1900 MHz LTE,CDMA and EVDO
- Nextel: 800/900 MHz iDEN/SMR
- Sprint PCS: 1900 MHz CDMA and EVDO
- T-Mobile: 1900/2100 MHz GSM and AWS
- Public Safety: VHF(150-174MHz), UHF(450-470MHz), 700/800 MHz
- Federal Government: VHF & UHF

Distributed Antenna Systems

Carrier Coordination

- Necessary to obtain permission from wireless service providers
- Purchased frequencies from FCC/US Government
- Re-transmission agreements
  - Repeaters or microcell/base station
- Potential RF issues generated
  - Noise floor, oscillation, frequency-specific, etc
- Carrier monitoring/database
- Coexisting with Public Safety systems

What Industry Solutions Are Available for Cellular Coverage ?

Wi-Fi Calling

Many businesses believe that Wi-Fi calling is an immediate fix for cellular connectivity problems

Network Extender

A network extender, sometimes called a femtocell or microcell. The device plugs into an existing broadband internet connection and works like a mini cell tower in your home or office.

Digital Apps

Digital applications may be the most commonly used cellular connectivity alternative. Offerings like Skype, Google Hangouts, and FaceTime boast accessible Voice over Internet Protocol (VoIP) and digital video communications solutions.

Active DAS

The most robust and infrastructure-intensive cellular connectivity solution is an active Distributed Antenna System (DAS). Active DAS offers a carrier- grade, high-capacity infrastructure solution for large venues.

An active DAS creates cell coverage within a building, using its own cellular signal. The system distributes signal between a centralized signal - “head end” source and “remote nodes” placed around a building

Passive DAS

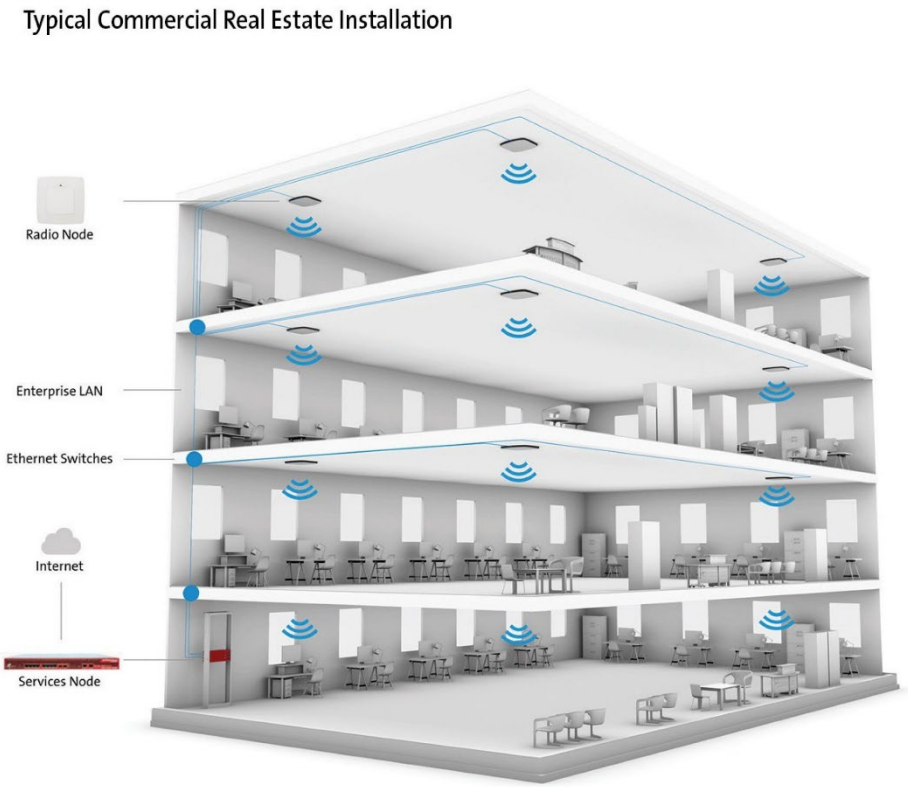
Passive DAS, also known as a cell signal booster system or bi-directional amplifier (BDA), enhances an existing signal with passive components and amplifiers. Antennas on the outside of a building capture the cellular signal and send it to a booster that amplifies the signal.

Less equipment than an active DAS, a passive DAS is a financially viable option for a wide range of users. **It is important to note that a passive DAS relies on the strength and quality of the available signal at the site to provide optimal cell coverage.**

Comparative Analysis of Systems

	 WI-FI	 NETWORK EXTENDER	 DIGITAL APPLICATION	 ACTIVE DAS	 PASSIVE DAS
CARRIER AGNOSTIC	YES	NO	YES	NO	YES
BUILDING SIZE	Unlimited	<7,500 sq ft	Unlimited	>500,000 sq ft	Unlimited
USER CAPACITY/ RELIABILITY	Low	Low	Low	High	High
SECURITY	Low	Low	Low	High	High
BUDGET	$	$	$	$ $ $ $	$ $
EASE OF INSTALLATION	Easy	Easy	Easy	Difficult	Moderate

Hybrid Solutions for Cell Coverage



What is an enterprise radio access network (E-RAN)? An E-RAN system is made up of one services node that manages a group of radio nodes (access points) that are attached to it. All of the radio nodes are powered by Ethernet, which makes them quick
and easy to install.

How does E-RAN work?

PoE+-powered radio nodes install on ceiling or wall

Radio nodes connect to services node over Ethernet LAN and internet

Services node connects to operator network over internet

Reliable cellular coverage and capacity inside buildings

PoE- Enabled System

E-RAN Platform

An E-RAN system is made up of one rack-unit-sized services node that manages multiple single-carrier or dual-carrier radio nodes operating in 3G, LTE, and unlicensed spectrum.

Services Node

The services node lies at the heart of the SpiderCloud® E-RAN solution. It ensures that the E-RAN system is easy to deploy and manage and that it delivers the performance mobile operators expect. The services node is access technology agnostic, supporting UMTS, LTE, and LTE-LAA. It orchestrates the self-organizing network (SON) process, controls the operation of different radio nodes during neighbor discovery, gathers information from different radio nodes, and creates optimized neighbor lists based on information received from the neighbor scans.

Hybrid Solutions for Cell Coverage

Radio Nodes

Like Wi-Fi access points, radio nodes are small with low profiles. An E-RAN platform offers a wide range of radio nodes for
many different applications and mobile operator configurations. All models are powered by PoE+ (802.11at) Ethernet switch ports.

Installation is quick and easy using commonly available PoE+.

1. Pull a structured cable (CAT 5e or greater).
2. Attach the radio to wall or ceiling.
3. Connect Ethernet patch cords at both ends.

Radio Node Family

Similar to a WiFi Access Point

Lighting Trends in Electric Sign Manufacturing

Looking at the future of LED use in signage

I believe that to understand the future, you must look at the past. This is my 18th year developing products specifically for the electric sign industry, and there has been a tremendous change.

When I started developing LEDs for commercial signage in 2003, I made a statement to a newspaper reporter that neon was a dinosaur. I was subsequently lectured by a few sign makers and tube benders that I was way out over my skis and that this LED thing was a flash in the pan.

Today, end-users are looking to light everything up on or around their building.

Early LED systems were bare PCBs with wire in between. There were various voltages and power sources (everyone who has been around a while remembers the GE dip switches that set the voltage depending upon the color). As with most disruptive technologies, early systems were overpriced and underperforming; however, unlike their neon predecessor, they could adapt and create new form factors. LEDs stuck.

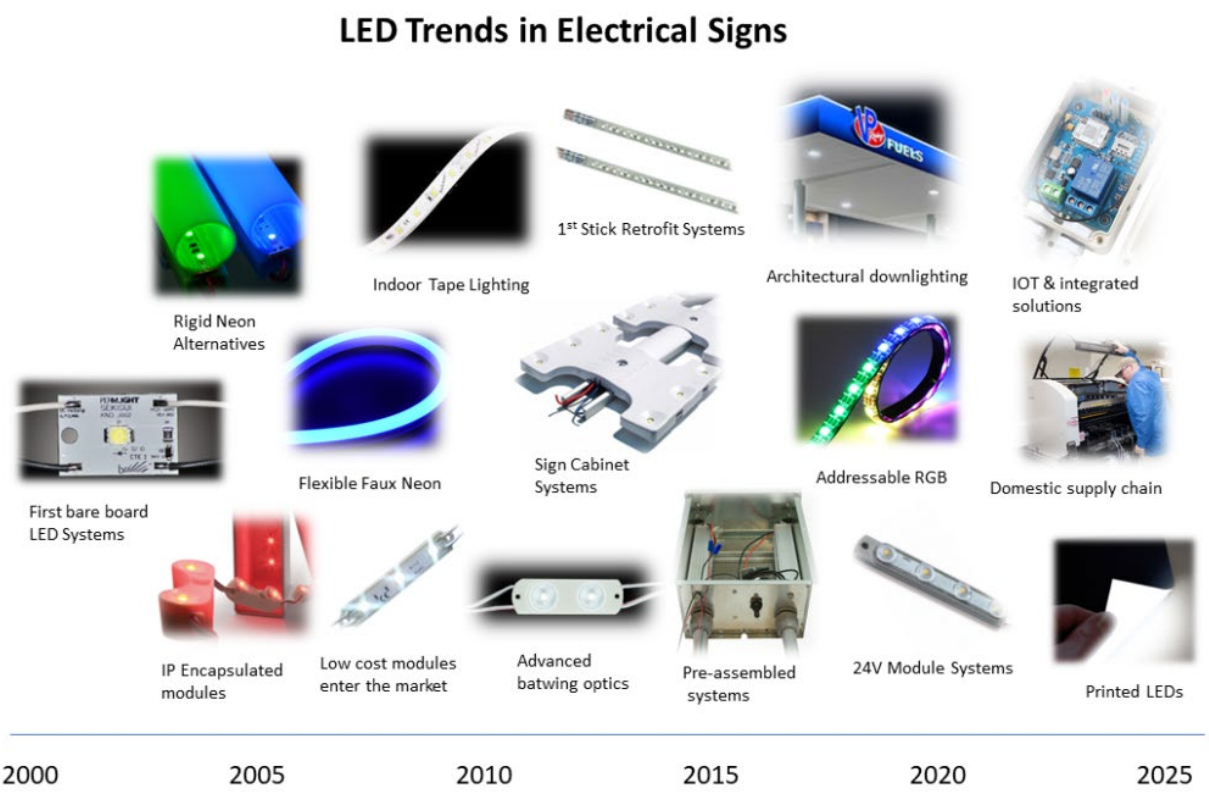
Early years

If you look back at the early years of LEDs in signs, the mission was simple: replace neon. Between 2000 and 2005, product development was focused on replacing the incumbent technology with modules in channel letters and rigid tubes in border applications. Between 2005 and 2010, flexible light tapes came onto the market to address needs in indoor signage, and flexible neon was developed as an alternative to exposed neon script. This second period really was around reducing costs, and around 2008, LEDs surpassed neon as the new lighting medium for the sign industry.

With LED manufacturers now in the pole position, they set their sights squarely on T-12 fluorescents, and again, everyone was skeptical. Just like during the heyday of LEDs in channel letters, there were a lot of systems out there for sign cabinets that varied from lattice to rail and module systems. What changed the cabinet market, particularly for sign retrofits, was when Principal LED came out with Stik that went straight into a socket. This product was preassembled in the USA, which allowed for a range of products "just in time" at a cost point that tipped the system. By the end of 2015, LEDs surpassed T-12 fluorescent lamps as the preferred technology of sign makers.

In 2015, however, technology development started to change, and between 2015 and today, direct material of LEDs and power sources began to be a smaller and smaller piece of the overall cost. It was now about system costs, and two major trends started in the industry.

The first was the development of 24V systems to reduce installation times and cost in large signs; the second was the use of kitting and preassembled systems for sign makers to reduce labor and time. Layered on top of this was a trend toward lower profile signs and the blurring of signage and architectural lighting, particularly in outdoor applications on and around building and gas canopies.



A timeline of LED trends in electrical signs. Be on the lookout for new technologies that move the cheese by creating new form factors or new manufacturing technologies and processes.

4 major trends

Now that we have looked back, it is time to look forward. I want to highlight four major trends that we'll experience over the next five years. These trends are a natural extension of application expansion and sophistication of offerings.

Growth in the domestic supply chain. With the current tariff situation and continued geopolitical risk with China, I believe more LED, and electrical manufacturers will onshore a portion of their production to North America. Domestic products mean that the just-in-time benefits that U.S. assembly created in the retrofit and kitting market can be applied at the module level. This will result in more readily available product options in stock for the sign maker, such as a full range of colors and color temperatures, spacing options, and lens choices.

Blurring of the lines between signs and lighting. As LEDs have become commoditized and the costs are a small part of the overall sign system, end users are looking to light everything up on or around their building. Sign makers are the trusted advisor for those customers. They have a great opportunity to move beyond signs into a range of interesting architectural products, including downlighting, linear lighting, and RGB and color-changing systems. With the cost-effectiveness of addressable RGB modules and IP-rated strips, sign makers can now design and create a range of unique lighting effects. Bitro Group offers full-color animation with its LightSymphony Signature system. I anticipate this area of the market will continue to grow.

LEDs have gone from replacing existing technology in neon and T-12 fluorescents to integration as a system, and now, the expansion of applications that offer a range of more sophisticated ways that they can be used.

Integrated systems and IoT. One growing trend that will continue is the integration of systems and tools for sign makers. Most LED suppliers have a range of tools to help sign makers sell to end-users. These include ROI and energy savings calculators, as well as estimating software. At Principal LED, we have a rebate group that helps sign makers take advantage of energy rebates. Sign/LED Wizard, provider of LED

layout software, now offers its integrated desktop product free of charge to sign makers. "…our production version allows sign makers to estimate costs of other materials and can be easily uploaded into a router to cut faces, and score and cut the back of the sign. We have plans to incorporate additional tools to assist in project management and sales," says Jeff Fassett, VP of business development.

Another part of integration in the future will be incorporating IoT into sign applications. The idea of smart signs that monitor energy consumption and can report outages will continue to grow. Colite has developed its own cloud system called Signalytix for monitoring and tracking of signage programs.

Printed LED technology. Interestingly, I ended up learning about and helping develop printed LEDs when I worked at Dow Chemical 20 years ago. The technology was very new and has been slow to develop. However, there is no question that end-users and sign makers want lower profile signage, and LED modules are inherently point sources. The name of the game is light distribution, and printed LEDs could be a disruptor to discreet LED modules in the sign industry over the next five years. Several companies have recently made real improvements in this space, and though not a current trend, it is something to look out for.

Trendsetting

When you look back at the history of LEDs in the sign industry (or any technology for that matter), you see a classic cycle. LEDs have gone from replacing existing technology in neon and T-12 fluorescents to integration as a system, and now expansion of applications that offer a range of more sophisticated ways that they can be used. Lines between traditional architectural lighting and signage will continue to blur, and systems will continue to be more integrated and streamlined. Finally, be on the lookout for new technologies that move the cheese by creating new form factors or new manufacturing technologies and processes.

StartUs insights

Telecom

Trend Report

StartUs insights

Innovation Intelligence at Your Fingertips

At **StartUs Insights**, we make the world's information on innovation, emerging companies, and technologies accessible. Our **Big Data & AI-powered Discovery Platform** covers over **2,5 million startups & scaleups globally**, making it the world's leading resource for data on emerging companies.

This technology enables you to identify what's next by quickly and exhaustively scouting startups, scaleups, emerging technologies & trends that matter.

StartUs insights

CONTENTS

StartUs insights

The telecom sector faces several looming challenges in the form of network load and infrastructure optimization, effectively addressing subscriber grievances to reduce churn, and improve security for telecommunications. The top 10 telecom industry trends directly address these challenges, in addition to improving the overall efficiency for telecom companies. Increasing global connectivity, further fuelled by the COVID-19 pandemic, presents numerous opportunities for telecom companies to reach more subscribers and offer innovative products and services. Smart factories, cities, homes, cars, and industrial workplaces require efficient and affordable cloud and 5G technology solutions, especially to address the growing number of connected people and things.

Covering over 2,5 million startups & scaleups globally, we use our Big Data and AI-powered Discovery Platform to identify innovative applications, technologies, and companies impacting the Telecom Industry. This exhaustive, data-driven startup scouting pinpoints emerging trends and technologies in the Telecom Industry. For this research, we analyzed a sample of 3 519 startups and scaleups and present the Top 10 Trends along with 20 highly relevant solutions.

In the Innovation Map below, you get an overview of the Top 10 Industry Trends & Innovations that impact telecom companies worldwide.

Innovation Map: Telecom

3519
Startups & Scaleups

- Internet of Things
- Connectivity Technologies
- 5G Network & Technology
- Artificial Intelligence (AI)
- High-Resolution Content
- Cybersecurity
- Cloud Computing
- Communication Models
- Software-Defined Networks
- Edge Computing

StartUs insights

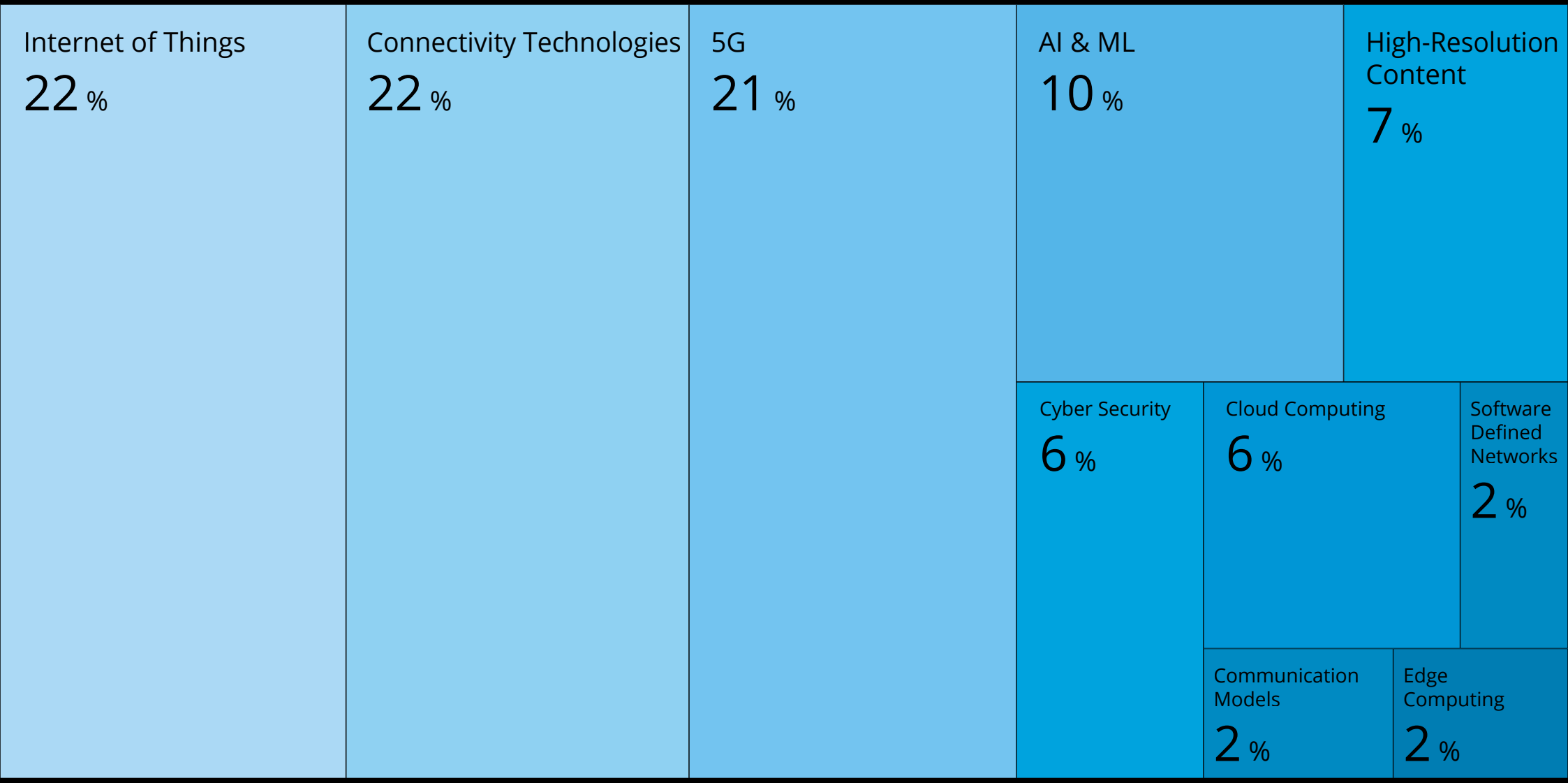
StartUs insights

Tree Map: The Impact Of Industry Trends On The Telecom Sector

Based on the Telecom Innovation Map, the Tree Map below illustrates the impact of the Top 10 Telecom Industry Trends. The internet of things (IoT) devices and sensors, connectivity solutions including next-generation WiFi and Bluetooth, as well the promise of 5G networks and technology dominate the top 10 telecom trends. Artificial intelligence (AI) algorithms influence data analytics and offer various opportunities for automation in the telecom sector. The penetration of smartphones and reliable internet generates large volumes of high-resolution content.

Telecom startups develop network solutions to manage and optimize speed and latency to further enable the growth of high-quality image and video content. In addition to these major telecom trends, the industry also sees the development of cloud and edge technologies for enabling smart industrial processes as well as solutions to improve human-to-machine and machine-to-machine communications. Get in touch with us to find relevant startups that impact your specific business.

Top 10 Telecom Industry
Trends & Innovations



StartUs insights | This tree map illustrates the top 10 innovation trends & their impact on the Telecom Industry

Global Startup Heat Map: Telecom Startups & Emerging Companies

The Global Startup Heat Map below highlights the global distribution of the 3.519 exemplary startups & scaleups that we analyzed for this research. Created through the StartUs Insights Discovery Platform, the Heat Map reveals that the US is home to most of these companies while we also observe increased activity in Europe as well Asia, particularly in India & Singapore.

Below, you get to meet 20 out of these 3.519 promising startups & scaleups as well as the solutions they develop. These 20 startups were hand-picked based on criteria such as founding year, location, funding raised, and more. Depending on your specific needs, your top picks might look entirely different.

StartUs insights

3519
STARTUPS ANALYZED

Global Startup Heat Map: Telecom

This Global Startup Heat Map illustrates the geographical distribution of 3519 startups & emerging companies we analyzed for this topic

StartUs insights

Internet of Things

IoT devices and sensors influence almost all industries of the technology economy. It improves people's quality of life, allows businesses to increase their profits, and improves management. IoT is also beneficial for governments looking to decrease their information technology (IT)-related expenses. Interconnection between devices, sensors, infrastructure, and computing elements further enables new ways for management. For example, decentralized operations, condition-based monitoring, and predictive maintenance ensure efficient communications between various IoT devices. In this way, IoT automates production processes and allows the implementation of Industry 4.0 concepts in the telecom sector.

Spanish startup N3uron develops highly customizable Industrial IoT and supervisory control and data acquisition (SCADA) software solutions to empower organizations to efficiently collect data. One of the startup's multiple integrated software modules, MQTT, uses special data-transfer protocols to connect thousands of field devices to any cloud or SCADA system. N3uron software runs on multiple operating systems and hardware without affecting performance. Moreover, the software's built-in networking security and data integrity checks follow industry standards of data formats. All of this allows companies to efficiently create and operate IIoT device networks.

British startup Iothic creates a communication protocol for the internet of things. The main benefit of the startup's solution is interoperability. The communication protocol enables companies to work on different devices and operating systems that are compatible with existing infrastructure. Further, a high level of security, with support for real-time low-latency operations, suits next-gen IoT applications, together with resistance to quantum decoding. The IoT standard helps manufacturers and customers by helping them reduce production and operational expenses.

Connectivity Technologies

Connectivity technologies are constantly evolving and include both wired and wireless communications. The development of communications technology is critical in today's IT-environment, with increasing data volumes, IoT devices, and people using the internet. Further, users increasingly share high-quality digital data, such as videos, photos, and music. All of these factors, along with the increasing use of satellite communications, contribute to the emerging telecom trends with innovation in connectivity technologies.

German startup FiSens manufactures Fiber Bragg Gratings (FBG) sensors for measuring strain, temperature, and pressure. The startup leverages the FBG effect, which allows creating chains without breaking fiber optics for data transmission. FiSens embeds sensors in the fiber optics, allowing up to 30 sensors in a single fiber. The startup produces FBGs for almost all possible spectral configurations. Additionally, these sensors are immune to electromagnetic interference and are safe in environments that involve radiation or explosions.

Sateliot is a Spanish satellite telecom operator for global continuous IoT connectivity, merging satellite and terrestrial networks under 5G protocols. Their hardware does not require any customization on the device side since satellite constellations act as a cell tower for IoT devices. Moreover, satellites handle messages in a secure and transparent way, ensuring customers' data is safe. Sateliot's connectivity solutions find applications in a wide range of industries, including utilities, maritime, oil & gas, and agriculture.

StartUs insights

5G Network& Technology

5G technology is the next big upgrade for telecommunication networks and devices. It provides a much higher speed, than previous cellular broadband network standards, and, most importantly, has much lower latency. Latency is very important for cloud gaming as well as VR content streaming. Massive machine-type communications (mMTC) that 5G networks provide enable the creation of high-density IoT networks, from IIoT to smart homes. Such wide-spread applications make 5G one of the most important upcoming technology trends for the telecommunication sector.

US-based startup Aarna Networks provides a multi-cluster orchestration platform – AMCOP. AMCOP automatically manages cloud infrastructure and connected networks, such as Edge networks. AMCOP supports 5G radio access networks (RAN), and 5G Core (5GC) orchestration, as well as network slicing, data analytics, and self-organizing networks (SON). Also, AMCOP is built on vendor-agnostic open-source software, helping businesses optimize their expenditures on network infrastructure and increase security.

Simnovus is an Indian startup, building efficient UE simulators for 5G networks. Based on software-defined radio (SDR) technology, the startup allows transforming traditional x86 hardware into a UE simulator. This agile and cost-effective solution is suitable for testing telecommunication equipment and developers of such equipment. The UE simulator provides testing with realistic patterns of traffic for different network technologies, extensive logging, and elaborate statistics. Further, the simulator's licencing supports up to 1000 devices.

Artificial Intelligence (AI)

Artificial intelligence (AI) and machine learning (ML) are other big telecom trends impacting the industry. Digital transformation requires the extraction of meaningful information from data, gathered by IoT sensors and devices. At the same time, the expansion and complication of the internet create the need for high speeds and low latencies, prompting new solutions for internet connection management. To this end, startups develop AI solutions that resolve numerous problems related to network performance.

NetOp is a startup from Israel, creating a critical network health utility tool using proprietary machine learning algorithms. The solution automatically analyzes the network, searching for any vulnerabilities. Using AI-powered advanced automation, NetOp proactively predicts and remediates network issues as they arise, which is beneficial for businesses wanting to improve their security and reduce operating costs.

The US-based startup IoT/AI offers an IoT platform that combines network connectivity, cybersecurity, and analytics operating in Edge networks. The platform analyzes the data from the mesh network locally using ML algorithms. In addition to military-grade cybersecurity, IoT/AI's sensor platform is suitable for the industrial, healthcare, defense, energy industries.

StartUs insights

High-Resolution Content

The penetration of smartphones and reliable internet leads to increased consumption of high-quality, and often heavy-to-transfer, content. The growth in high-resolution content, in turn, drives improvements in the quality of traditional information media such as videos, pictures, and music. Novel telecommunications help businesses adapt to new types of information media, such as virtual, augmented, and mixed reality- (VR/AR/MR) and cloud-based gaming. These new types of content require not only high-speed transmission but also low latency, prompting startups to develop high-capacity telecommunication networks.

Subspace is a US-based startup building networks specifically for online multiplayer games. To reduce lag and create a seamless experience for gamers, the startup uses a combination of hardware and software solutions. These include custom network routing hardware built for accelerating games and software to protect the integrity of the game. Together, these measures lead to higher player retention, matchmaking pools, and revenue for studios as well as publishers.

US-based startup echoAR creates tools to facilitate 3D application development, improve its deployment, and manage related procedures. The tools focus on cross-platform AR/VR programs development. While most AR/VR applications today support single-user, single-device static experiences, the startup's flexible cloud infrastructure makes content management & delivery simple. By making possible AR/VR products, deployable everywhere, the solution benefits brands and enterprises seeking to improve their consumers' experiences.

Cybersecurity

The increasing number of cyber-attacks and low-security IoT devices, new central processing unit (CPU) hardware vulnerabilities, and the growing dependence on computing infrastructure make tackling security risks challenging. In any industrial network, systems are continuously managed in an attempt to stay ahead of evolving cyber threats, but these methods often conflict with the network's core requirements of reliability and availability. Startups innovate industrial networks by allowing systems to remain dynamic when faced with attacks or vulnerabilities.

Cybersenshi is a startup from Saudi Arabia developing a cybersecurity tool that discovers and fixes customers' website & network security weaknesses. The database covers over 130.000 cybersecurity weaknesses of websites, networks, systems & databases. It is suitable for both small businesses, without deep knowledge in cybersecurity as well as for medium and big businesses.

US-based startup Quantum Xchange develops Phio TX and Phio Quantum Key (QK). Phio TX works on current network infrastructure, improving communications security and making existing key infrastructure quantum-safe. For a higher security level, quantum keys are used in combination with Phio TX over any type of data transmission. Further, Phio TX requires low infrastructure, which is beneficial for companies looking to bolster security.

StartUs insights

Cloud Computing

Cloud computing is a fast-growing technology trend within telecommunications. The spreading of IoT devices and the use of more sophisticated ML algorithms leads to the high demand for computing power. There are many benefits of migrating data, applications, and other business elements to a cloud computing environment. From equipment, platforms, infrastructure, and company functions, startups bring greater connectivity and integration solutions for businesses. All connected environments, from cities and factories to houses and cars, require improvements in cloud integration technologies.

Swedish startup Cloud Backend provides a platform for subscription, data policies, and resource budget allocation using a web-based dashboard. The dashboard's architecture scales to multiple edge nodes, providing automatic synchronization and caching to secure network operations in case of failure. Cloud Backend's architecture is also suitable for enterprises expanding or optimizing their networks and systems.

Purestake is a US-based startup developing an Infrastructure-as-a-Service (IaaS) platform that delivers consistent uptime and availability. The startup combines the best practices in network architecture and security operations. The platform disperses nodes globally and, based on an automated multi-pop and multi-cloud approach, the service spans Amazon Web Services (AWS), Microsoft Azure, and Google environments. Further, the security of blockchain networks allows companies to build resilient, auto-managed networks for their needs.

Communication Models

The spread of smart and IoT devices also leads to an increase in communication channels, such as machine-to-machine (M2M), vehicle-to-everything (V2X), device-to-device (D2D), human-to-machine. Communication models differ in the connectivity technologies they use from hardware to software. Communication models are combined under include next-generation WiFi & Bluetooth, which are the basis for new products and technologies for a wide range of companies – from large banks and car manufacturers to startups and scaleups.

Indian startup M2Cloud creates device-to-cloud (D2C) solutions. They produce both simple and advanced vehicle tracking devices, aimed at creating an intelligent transport system to optimize existing public transport infrastructure. Additionally, M2Cloud produces wall-mounted sensors, both ultrasonic and infrared, for measuring body temperature. It is especially useful for establishments to check their customers and workers during the COVID-19 pandemic. M2Cloud tracking devices also use eSIMs to easily connect to the cloud.

Angoka is a British startup providing hardware solutions for managing cybersecurity risks inherent in M2M communication networks. The startup aims to improve security for connected and autonomous vehicles, smart city services, electrical grids, and banking networks. The solution provides hardware authentication using a decentralized cryptographic protocol. Angoka's solution also enables silicon devices fingerprinting based on their physical properties, which then allows for generating cryptographic keys and secure device identity.

StartUs insights

Software-Defined Networks (SDNs)

In today's increasingly digital environment, business applications require high-performing and extensive networking operations. Particularly for cloud computing, it is essential for businesses to deploy, manage, and support connectivity across a variety of environments. Typically, complex tools are required to build and manage modern software-defined networking technology. Some vendors only provide solutions that work on their equipment, which then limits the extent of communications capabilities. . Startups develop SDN to improve network performance, monitor its performance, and enable centralized control.

UK-based startup EdgeNEXUS develops network load-balancing solutions for SDNs. edgeNEXUS optimizes routing changes based on a number of factors including load volume and application performance, thus adding a layer of intelligence between applications, networks, and SDN controllers. The startup's Global Server Load Balancer (GSLB) provides tools for multi-datacenter, multi-cloud, and hybrid cloud load balancing and failover. GLSB is suitable for enterprises looking to control their application delivery service depending on user or region.

Ethica is a Canadian startup providing CloudAccess, an easy-to-deploy and inexpensive Software-Defined Wide Area Network (SDWAN) solution focusing on SMEs. The solution reduces the downtime of the network by aggregating multiple internet connections and using them when they are available. Also, CloudAccess provides Quality of Service (QoS) by prioritizing more important types of traffic which is useful, for example, in distributed teams using video calls. Further, all the solution's features are manageable through a cloud-hosted orchestration utility.

Edge Computing

Edge computing brings data computation and data storage closer to the source of data instead of a centralized remote cloud. This reduces latency, increases bandwidth, and simplifies maintenance while it allows industrial manufacturing companies to expand their computing capacity by combining devices with edge data centers at lower costs. Lower latencies and high speeds are required for modern applications, like cloud gaming and VR. Edge Computing greatly improves the quality of experience for end-users and lowers data exchange requirements.

Belgian startup Edgegap provides Edge network-based game hosting services. By locating online game-hosting servers in close proximity to the actual players, the startup ensuring low latencies. Edgegap currently has 220 hosting locations available. Moreover, the services are easily scalable and reliable. Edgegap provides equal latencies for all players connected to a single game, ensuring fairness, which is very important in competitive gaming.

US-based startup Axellio builds FabricXpress – a high-performance, high-density computing and storage platform for heavy applications. This solution is suitable for Edge networks that have a high density, high bandwidth, and low latency requirement. In addition to improving network performance, the startup achieves this with a small energy footprint and low costs.

What Does This Mean For Telecom Companies?

The innovation areas outlined in this research on 10 Telecom Industry Trends only scratch the surface of what we found during our analysis. 5G networks and technology implementation, flexible networks for high- and low-latency requirements, and faster modes of communication are all areas bound to significantly impact telecom companies one way or the other. Identifying new opportunities and emerging technologies to implement into your business early on goes a long way in gaining a competitive advantage and becoming an industry leader.

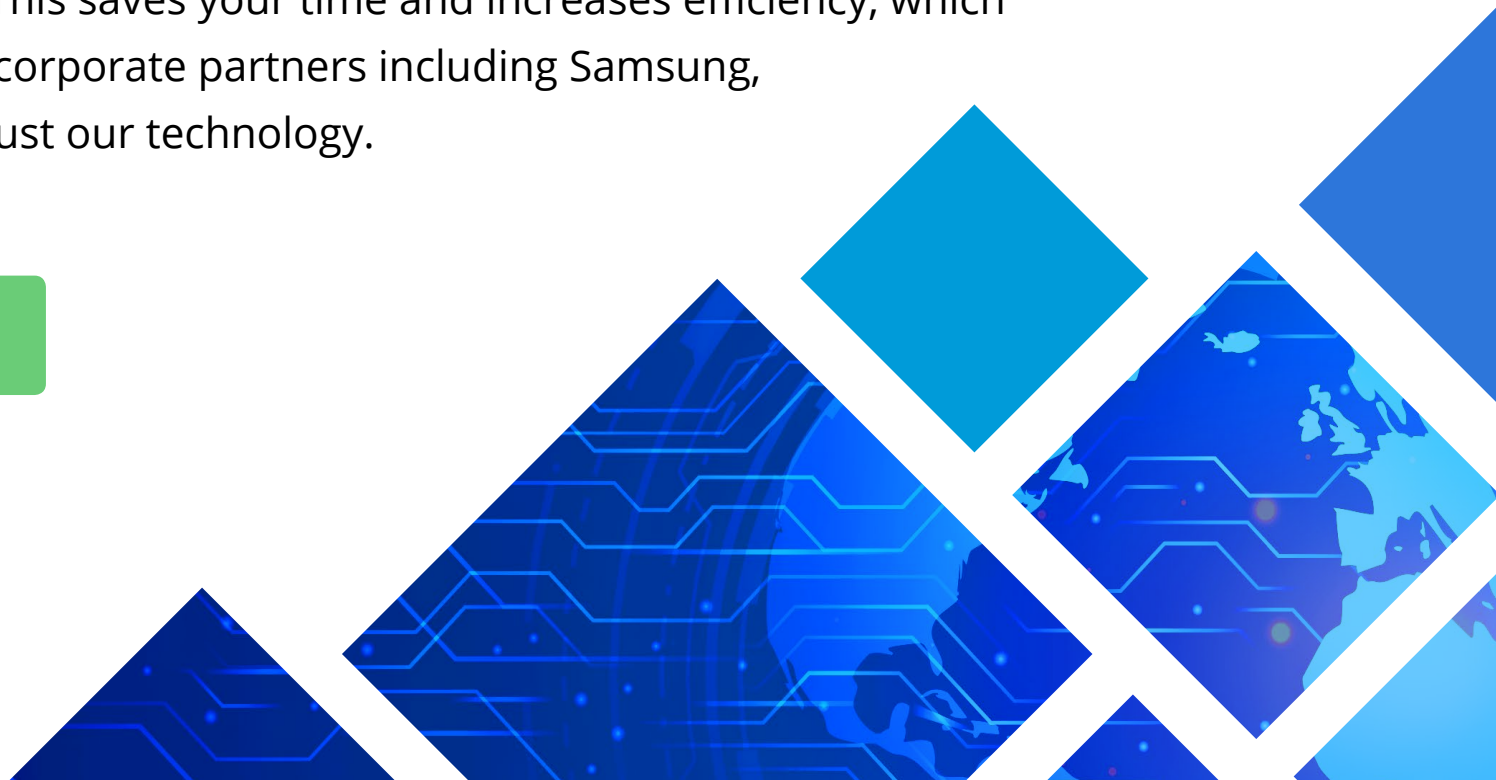
The Telecom Industry Trends & Startups outlined in this report only scratch the surface of trends that we identified during our in-depth research. Among others, AI, 5G, and connectivity innovations will transform the sector as we know it today. Identifying new opportunities and emerging technologies to implement into your business early on goes a long way in gaining a competitive advantage. Get in touch to easily and exhaustively scout relevant technologies & startups that matter to you.

StartUs insights

Identify What's Next

The [StartUs Insights Discovery Platform](#) covers over **2,5 million startups & scaleups globally** – making it the world's largest resource for data on emerging companies. The SaaS Platform enables you to **easily**, **quickly**, **and exhaustively scout relevant companies**, **technologies**, **& trends** for your innovation activities. This saves your time and increases efficiency, which is why more than 650 leading corporate partners including Samsung, Kyocera, and Nestlé already trust our technology.

Schedule Free Demo



Share this:

- Click to share on Facebook (Opens in new window)
- Click to share on Twitter (Opens in new window)
- Click to share on LinkedIn (Opens in new window)
-

Discover the Top 10 Power Distribution Trends in 2025

Will technology help solve the challenges around power generation and distribution? This data-driven research focuses on the top 10 power distribution trends, based on our analysis of 955 emerging companies. These trends include microgrids, DERs, energy storage systems, digital twin & more!

Related topics: ADVANCED ENERGY STORAGE SYSTEMSASSET MANAGEMENTCYBERSECURITYDERSDIGITAL TWIN

The power distribution sector addresses the challenges of enhancing energy accessibility, improving system reliability, and reducing environmental impacts amid rising energy demands. Innovative technologies like microgrids, photovoltaics (PV), wind energy, and advanced energy storage systems (ESS) increase the efficiency, security, and resilience of power distribution infrastructures.

These advances significantly impact the energy sector and also industries such as manufacturing, retail, healthcare, and transportation, which rely heavily on a continuous power supply. This report explores the latest trends and innovations shaping the power distribution landscape, providing insights for industry experts seeking to navigate and leverage these developments. Read more to explore the top 10 power distribution trends in 2025 and how they streamline access to energy.

This article was last updated in August 2024.

Top 10 Future Trends in Power Generation (2025)

1. **Microgrids**

2. Distributed Energy Resources
3. Advanced Energy Storage Systems
4. Resiliency & Disaster Management
5. IoT in Power Distribution
6. Cybersecurity
7. Energy Trading
8. Virtual Power Plants
9. Asset Management for Power Distribution
10. Digital Twin

Innovation Map outlines the Top 10 Power Distribution Trends & 20 Promising Startups

For this in-depth research on the Top Trends in Power Distribution & startups in the field, we analyzed a sample of 955 global startups & scaleups. This data-driven research provides innovation intelligence that helps you improve strategic decision-making by giving you an overview of emerging technologies in the energy and utility industry. In the Power Distribution Innovation Map, you get a comprehensive overview of the innovation trends & startups that impact your company.

Want to explore all power distribution innovations & trends?

Request Sample Database

These insights are derived by working with our Big Data & Artificial Intelligence-powered **StartUs Insights Discovery Platform**, covering 4.7M+ startups & scaleups globally. As the world's largest resource for data on emerging companies, the SaaS platform enables you to identify relevant technologies and industry trends quickly & exhaustively.

Tree Map reveals the Impact of the Top 10 Power Distribution Technology Trends in 2025

Based on the Electricity Distribution Innovation Map, the Tree Map below illustrates the impact of the Top 10 Future Trends in Power Distribution. Innovations in microgrids and distributed energy resources (DERs) decentralize power generation, offering flexible and localized solutions to enhance energy accessibility. Meanwhile, advanced energy storage systems (ESS) ensure consistent energy supply and balance demand loads. Coupled with comprehensive resiliency and disaster management strategies, these technologies build robust energy systems that withstand adverse scenarios.

Besides, the Internet of Things (IoT) provides real-time monitoring to optimize energy consumption. At the same time, cybersecurity solutions protect critical infrastructures from threats. Energy trading and virtual power plants (VPPs) are enabling more democratic and efficient exchanges by streamlining asset management and maintenance. Lastly, digital twins

provide a virtual platform for simulating and optimizing system performance, paving the way for a digital and resilient energy future.

Download High-Res Visual

Share this:

- *Click to share on Facebook (Opens in new window)*
- *Click to share on Twitter (Opens in new window)*
- *Click to share on LinkedIn (Opens in new window)*
-

Global Startup Heat Map covers 955 Power Distribution Startups & Scaleups

The Global Startup Heat Map below highlights the global distribution of the 955 exemplary startups & scaleups that we analyzed for this research. Created through the StartUs Insights Discovery Platform, the Heat Map reveals high startup activity in the US and Western Europe, followed by India.

Below, you get to meet 20 out of these 955 promising startups & scaleups as well as the solutions they develop. These electricity distribution companies are hand-picked based on criteria such as founding year, location, funding raised, & more. Depending on your specific needs, your top picks might look entirely different.

Download High-Res Visual

Share this:

- *Click to share on Facebook (Opens in new window)*
- *Click to share on Twitter (Opens in new window)*
- *Click to share on LinkedIn (Opens in new window)*
-

Top 10 Trends in Power Generation (2025)

1. Microgrids

Power distribution networks in many regions of the world face a multitude of issues including inefficiency, lack of resilience, and central control. Microgrids are small-scale localized power system alternatives that address these challenges by combining decentralized energy generation, distribution, and storage.

Additionally, microgrids optimize energy consumption through the implementation of smart grid technologies such as real-time monitoring and demand response. This also ensures better load balancing and provides more reliable power to remote or underserved areas.

Sunkofa Energy offers Off-Grid Mini Grids

French startup **Sunkofa Energy** develops solar-powered mini-grids for residential, tertiary, and industrial applications. The startup's solution combines photovoltaic (PV) panels, batteries, power electronics, and smart metering systems. Moreover, its modular design enables the expansion of the system's capacity in increments of 10kW. In addition, the startup's grid service supports payment via mobile money, improving accessibility. The startup's solution also features customer management, demand stimulation, and data analytics to reduce the cost of operating mini-grids.

CE+T Energrid simplifies Microgrid Power Management

CE+T Energrid is a Belgian startup that provides an advanced energy management system to optimize the use of renewable energy systems. The startup's power management system (PMS) streamlines energy flows using storage solutions and smart controls. The PMS also charges or discharges the battery storage system to maximize self-consumption and peak shavings without any direct intervention.

CE+T Energrid's PMS integrates with external energy management systems (EMS) to optimize consumption and production. This way, energy companies leverage real-time weather forecasting and data from energy markets. The startup's solutions find applications in remote areas to provide self-sustainable power by connecting loads, renewable energy sources, and batteries to the grid.

2. Distributed Energy Resources

Limited access to electricity due to inadequate grid infrastructure is one of the main challenges in remote areas, especially in developing countries. That is why startups are deploying DERs, leveraging solar panels, wind turbines, energy storage systems, and microturbines.

By leveraging DERs, power distribution becomes more resilient and reliable, reducing the impact of outages caused by storms or other disruptions. Further, DERs enable mini-grids and microgrids, bringing electricity to off-grid and underserved areas. These solutions contribute to more decentralized and sustainable power distribution systems. This improves energy access, grid reliability, and clean energy adoption.

Xendee aids DER Portfolio Analysis

Xendee is a US-based startup that offers a platform for optimizing DERs and microgrid sites. The startup's *DISCOVER* tool integrates with internal and external data sources, including data on technology, tariff, energy load, and weather, to identify optimal sites. Besides, the tool offers insights into site-specific capital and operating expenditure, potential revenue generation, and carbon savings.

The startup also offers *OPERATE*, a plug-and-play EV charging and microgrid controller. It automates system management using AI and machine learning. Xendee's platform enables grid and utility operators to analyze and prioritize customer site portfolios for potential DER and microgrid locations.

Lunar Energy facilitates Home Electrification

Lunar Energy is a US-based startup that offers a comprehensive energy management platform – *Lunar Gridshare*. It optimizes a large number of DERs in dynamic markets by connecting with third-party devices such as smart meters, IoT devices, and energy storage systems. Through this, the platform gathers real-time data to predict energy usage patterns at both household and fleet levels. This predictive capability allows for better energy allocation, reducing costs, and improving overall energy management.

Lunar Energy also offers *Lunar System*, a solution that combines a battery, bridge, maximizers, and a companion app. It uses solar panels to capture, store, and control energy. The startup's energy management solution solves the problem of intermittent power supply and minimizes outages.

3. Advanced Energy Storage Systems

The production of energy is not constant at all given times and therefore compounds issues such as inadequate load balancing and peak demand management. Advanced energy storage systems feature large-scale batteries, flywheels, and compressed air energy storage. They enable the storage of excess electricity during periods of low demand and its release during peak demand periods.

By integrating ESS into power distribution networks, operators enhance grid stability, improve voltage regulation, and optimize the utilization of renewable energy sources. Additionally, advanced ESSs facilitate the integration of intermittent renewables, like solar and wind, by compensating for fluctuations.

Advanced Microgrid Solutions develops Vanadium Redox Flow Batteries

Advanced Microgrid Solutions is a Singaporean startup that provides affordable microgrid power generation solutions. The startup's *VFlowTech* vanadium redox flow battery has a higher energy density than conventional solutions. It also reduces parasitic losses, features low setup costs, and minimal maintenance requirements.

The startup also utilizes additives to support wider operating temperatures. Besides, it offers a range of products, including the *PowerCube* series, for applications such as residential storage, telecom towers, solar trackers, and off-grid solutions.

Visionary manufactures a Portable Power Station

US-based startup **Visionary** specializes in energy storage for power distribution grids. Its decentralized energy storage solution delivers reserve energy for longer periods when the primary power source is unavailable. The startup also offers the *Power Kubik*, a portable power station with green energy backup. *Power Kubik* comes in two types of boxes – for energy backup and voltage stabilizing – providing safety for electric devices at home and charging gadgets on the go.

Visionary's *Power Module* is a scalable power backup with a capacity of 6500W as well as features for advanced analytics and remote data management. Moreover, Visionary's cloud service aggregates distributed *Power Module* units into virtual energy storage, supporting the local grid and improving the efficiency and reliability of the power grid.

4. Resiliency & Disaster Management

Natural disasters, such as hurricanes, earthquakes, and wildfires, pose a major threat to power infrastructure, leading to prolonged outages and disruptions. Additionally, aging grid infrastructure and inadequate preparedness for extreme weather events exacerbate the problem. Advanced technologies, including predictive analytics and real-time monitoring systems, enable early detection and rapid response to such issues.

The integration of microgrids and decentralized energy systems further enhances resiliency by providing localized power generation and storage. This ensures continuity during grid failures. Moreover, grid hardening measures, such as underground cabling and reinforced infrastructure, improve the infrastructure's ability to withstand natural disasters, preventing outages and enhancing the resilience of the electric grid.

RPower provides Grid Resilience-as-a-Service (RaaS)

US-based startup **RPower** specializes in a range of power generation and energy management solutions including microgrids and resilience-as-a-service. The startup's resilience-as-a-service solution ensures reliable, uninterrupted power and it also offers the design, installation, operation, and maintenance of microgrid systems.

RPower's microgrid solutions improve resiliency and offer cost savings, focusing on both island mode operation and grid-synchronized systems. The startup also provides a design-build-transfer option for customers who prefer to own the microgrid equipment. RPower's services enhance the operational resilience of power distribution infrastructure and services.

CellCube improves Critical Asset Protection from Power Outages

CellCube is an Austrian startup that specializes in long-duration energy storage systems using sustainable energy. The startup utilizes vanadium redox flow battery technology to store and shift renewable energy. CellCube's system supports various applications, including integration with renewable energy, microgrids, and off-grid storage.

Moreover, the startup provides long-duration backup energy storage systems for outage protection. This offers security for critical infrastructure like hospitals, utilities, etc., ensuring a reliable energy supply. Furthermore, it is capable of supporting businesses with more than 12 hours of backup electricity each day. It also features a maximum power draw at 200% of its nominal power to ensure minimal interruption. CellCube's solutions strengthen the resilience of operations, offering a reliable backup solution with a fast response time in the event of power outages.

5. IoT in Power Distribution

Consumers are consistently facing rising energy costs due to the lack of real-time monitoring, inefficient energy consumption, and limited grid intelligence. Therefore, energy utility companies are integrating smart meters, sensors, and automation systems into power distribution networks. This way, they gain real-time visibility and control over energy flow.

Moreover, IoT enables proactive maintenance to identify potential issues early on and optimize asset management. IoT-enabled smart grids also facilitate demand response programs, allowing consumers to adjust their energy usage based on real-time price signals. This results in reduced peak demand and improved grid efficiency.

Inclusive Energy enables Remote Energy Asset Monitoring

Inclusive Energy is a UK-based startup that creates software and hardware for the monitoring and maintenance of biogas digesters. The startup's *Smart Biogas* is a real-time monitoring system that utilizes IoT sensors to monitor digester health and sends data to the cloud.

Additionally, its small off-grid energy kit, *Micro-Power*, uses a smart charge controller, *Cloud Solar*, to enable remote monitoring and control. Besides, the startup's *Street Smart* range of solar street lights assists utility operators with real-time solar asset management, controllable electricity output, and remote management.

nLine facilitates Critical Energy Infrastructure Monitoring

US-based startup **nLine** provides sensors and analytics to measure and improve energy systems like microgrids and national grids. The startup's *GridWatch* technology offers remote monitoring of power quality and reliability using a novel sensor that plugs into outlets. The platform also delivers automatic notifications when sensors go down and also aggregates grid-wide metrics in a live dashboard. This data allows operators to improve the performance of critical infrastructure and support sustainable energy use through real-time reporting.

Find out how 10 **emerging technologies shape your industry!**

6. Cybersecurity

Utilities are digitizing power grids to achieve transparency and efficiency but, at the same time, increasing the exposure to malicious attacks. They disrupt essential services through cyber attacks, data breaches, and unauthorized access. Therefore, energy distributors are leveraging innovations in cybersecurity to mitigate these risks.

Advanced encryption, network segmentation, and robust authentication mechanisms secure communication and data exchange within power distribution systems. Additionally, continuous monitoring, threat detection, and incident response systems identify and respond to potential cyber threats promptly. These solutions safeguard the power distribution systems to ensure uninterrupted delivery of electricity.

Splight offers AI-based Security for Power Distribution Assets

Splight is a US-based startup that develops a proprietary AI platform for grid security. It features a neural network framework with interconnected layers. The platform collects grid asset data through networks and proprietary connectors to address problems in electricity generation, storage, and transmission.

Besides, Splight's remote monitoring platform functions with just a basic internet connection and any industry protocol as well as includes cybersecurity layers. Through this solution, power grid operators secure their digital assets and facilitate the monitoring of energy infrastructure and energy generation.

Utiltyx aids Grid-Edge Device Monitoring

Utiltyx is a US-based startup that safeguards complex power grids and their interconnectivity from external cyber threats using its *GRID EYE* platform. Its DER-aware cybersecurity solution for smart grids utilizes AI-powered monitoring to analyze anomalies, detect malware, and prevent intrusions.

Additionally, the platform offers comprehensive visibility of all connected devices on the grid, facilitating incident response. Utiltyx also provides custom software development, integration projects, security assessments, data engineering, and cloud enablement services. The startup's product and services ensure effective defense against potential cyberattacks on critical energy infrastructure.

7. Energy Trading

The current energy trading sector is highly complex and fragmented. It involves various participants, including power generators, retailers, brokers, and consumers, each with different objectives and requirements. Solutions such as blockchain technology enable peer-to-peer (P2P) energy exchange, allowing consumers and prosumers to remove intermediaries. This decentralized approach promotes transparency, enhances market efficiency, and facilitates the integration of renewable energy sources into the grid.

Further, smart contracts and automated trading platforms streamline energy transactions by ensuring secure and reliable settlements. Real-time data analytics and forecasting tools further provide insights into energy supply and demand. This enables more accurate pricing and efficient energy allocation. Through these innovations, energy trading becomes more dynamic, accessible, and resilient, fostering a customer-centric power distribution ecosystem.

Jua.ai provides AI-powered Weather Forecasting for Energy Trading

Jua.ai is a Swiss startup that offers an AI-powered weather forecasting model for energy trading. The company's technology utilizes a weather model built on a large dataset. This model predicts weather with high accuracy, precision, and speed. The technology also leverages uncorrelated data sources to provide improved temporal accuracy and pinpoint the exact timing of

weather events. Therefore, the startup enables early identification of major weather events and enhances decision-making for renewable energy trading.

Granular Energy enables Clean Energy Trading

Granular Energy is a French startup that provides a clean energy trading platform. It streamlines the management of energy attribute certificates, automates the allocation to end-consumers, and optimizes the sourcing and trading of certificate portfolios. The platform also offers real-time transparency, automated portfolio management, and risk management tools. Granular Energy thus facilitates the transition to a carbon-free electricity system while allowing utilities and energy managers to meet their sustainability goals.

8. Virtual Power Plants

Rapid urbanization burdens power distribution networks, causing grid congestion, poor integration of DERs, and inadequate demand response. As a result, startups are developing virtual power plants that leverage software and control systems to aggregate and orchestrate a network of diverse energy resources. They include solar panels, battery storage, electric vehicles (EVs), and more.

By integrating energy resources into VPPs, operators gain enhanced flexibility in managing electricity supply and demand. They enable better grid optimization, load balancing, congestion management, and renewable integration. Moreover, VPPs provide the framework for effective demand response programs and enable energy companies to mitigate the issue of intermittency in renewable grids.

Evergen optimizes Digital Energy Supply Chain

Evergen is an Australian startup that provides a platform to optimize the digital energy supply chain. The platform leverages virtual power plants to manage distributed energy resources (DERs) such as solar panels, batteries, and electric vehicles. It also uses machine learning to enhance the efficiency and performance of these assets, allowing for real-time monitoring and

control, extensive reporting, and customizable dashboards. The platform also ensures lower energy costs for consumers, increases grid stability, and supports renewable energy integration.

Lumena Energy specializes in Energy-as-a-Service

Lumena Energy is a US-based startup that aids energy demand response with virtual power plants. The startup's VPP enables customers to participate in peer-to-peer energy trades during high-demand periods, earning rewards as a result. It also creates a decentralized network that leverages AI to efficiently respond to supply and demand. This system stabilizes the power grid and also reduces reliance on costly power plants.

Further, Lumena Energy's Parsecc platform utilizes IoT to interconnect prosumers' solar power systems with others in their grid. Furthermore, the platform allows users to monitor their system, engage in energy trading, and exercise voting rights among users, local government, and infrastructure providers.

9. Asset Management for Power Distribution

Utility operators spend considerable resources in managing assets to counter aging infrastructure, inefficient maintenance practices, and suboptimal resource allocation. These issues lead to increased downtime and operational costs. To tackle these issues, energy companies leverage predictive analytics, machine learning, and Internet of Things (IoT) sensors to monitor equipment health and performance in real-time.

Such solutions facilitate proactive maintenance and reduce unplanned outages. Additionally, asset management systems incorporate data-driven decision-making processes to optimize resource allocation and prioritize investments in critical infrastructure. These measures enhance the efficiency, reliability, and lifespan of power distribution assets, ensuring a more resilient and cost-effective electricity supply.

Airpelago delivers Drone Inspection Services

Airpelago is a Swedish startup that provides end-to-end inspection services of power lines for utility providers. The startup's software *Airpelago Power* is a solution for large-scale inspection of power lines. It utilizes drones and ensures consistent data quality crucial for effective AI analysis. The startup automates the entire process, from flight planning to data management, also offering live progress tracking along with features for cooperation between pilots.

Airpelago Power provides power line inspection for storm damage and service line defects. It also performs infrared and LiDAR-based inspection for high-detail imaging and point cloud generation of powerline infrastructure. This safer and greener alternative is more efficient and cost-effective than traditional manual inspection methods in detecting powerline faults and defects.

enSights simplifies Renewable Energy Asset Monitoring

enSights is a US-based startup that provides energy optimization technology for renewable energy portfolio management. The startup's platform combines AI and machine learning algorithms to optimize the efficiency and productivity of renewable energy assets. The solution also offers real-time operational, maintenance, and financial visibility into all connected assets.

Additionally, the platform features live performance monitoring, corrective and preventive maintenance, advanced reporting, and more. These features enable energy asset investors and owners to better manage their portfolios, returns on investment (ROI), and profits.

10. Digital Twin for Electric Grids

Many utility operators suffer from limited visibility into network operations, lack real-time situational awareness of their assets, and have difficulty managing infrastructure upgrades. Digital twins overcome these problems by delivering virtual replicas of the physical power distribution system. They combine real-time data from sensors, communication networks, and other sources to provide a comprehensive and dynamic representation of the power distribution network.

By leveraging advanced analytics and simulation capabilities, digital twins enable operators to monitor, analyze, and predict the behavior of the power system in real-time. Moreover, digital twin platforms facilitate scenario analysis and what-if simulations. This enables grid operators to assess the impact of infrastructure upgrades, renewable energy integration, and demand variations.

Plexigrid develops Software for Distribution System Operators

Plexigrid is a Swedish startup that provides grid-centric flexibility management systems. The startup's solution leverages a real-time digital twin and comprises three technology layers – a smart meter, advanced analytics, and modeling. Its grid analytics tool *Tatari* aids distribution network planning and operation and offers real-time digital twin simulations of a grid's past, current, and future states.

The startup also leverages advanced analytics to simulate three-phase unbalanced networks across voltage levels. Lastly, it aids in modeling, forecasting, and controlling of DERs. Further, Plexigrid's products *Ari* and *Tatari* consolidate all grid data in one place, enabling network operators to improve monitoring and analytics performance.

Gradyent creates a Digital Twin for Heating Grids

Gradyent is a Dutch startup that offers a real-time digital twin Platform for the optimization and decarbonization of heating grids. It creates a digital copy of the entire heating grid by incorporating geographical, weather, and sensor data as well as physics-based models and AI. The platform then provides comprehensive insights into the network, even for areas lacking data or smart meters. This allows for enhanced grid optimization and future scenario simulations.

The platform also features real-time monitoring, automated data validation, thermohydraulic solvers, demand forecasting, and live setpoints for dynamic temperature control. Gradyent's solution thus improves grid performance, reduces CO2 emissions, lowers operating costs, and supports the integration of renewable energy sources. By enabling district heating companies to

achieve higher efficiency and sustainable operations, Gradyent accelerates the transition to a carbon-free heating system.

Discover all Electricity Distribution Trends, Technologies & Startups

Grid optimization software that utilizes machine learning, AI, and digital twins is enhancing the responsiveness and efficiency of current and future power grids. Further, smart grids dynamically balance renewable energy output by integrating multiple sources of renewable energy for grid stability. Innovations in ultra-high voltage transmission lines are further enabling long-distance, low-loss power transmission.

Meanwhile, blockchain technology in energy trading fosters increasing transparency and reducing energy transaction costs. The power distribution trends and startups outlined in this report only scratch the surface of trends that we identified during our data-driven innovation & startup scouting process. Identifying new opportunities & emerging technologies to implement into your business goes a long way in gaining a competitive advantage.