Board of Building Standards

EDUCATION COMMITTEE MEETING AGENDA
REVISED MARCH 29, 2023

DATE: MARCH 30, 2023
TIME: 10:00 AM
LOCATION: BBS LIBRARY, 6606 TUSSING ROAD, REYNOLDSBURG, OHIO 43068
Click here to join the meeting

Call to Order

Consent Agenda

Course Applications

ER-1 2024 IBC, IRC, IFC Sneak Peak (ICC)
All certifications (4 hours)
Staff Notes: 2024 IBC and IFC not being considered for adoption at this time. 2024 IRC not yet in rule development process. Not recommended for approval.
Committee Recommendation:

ER-2 One- and Two-Family Dwelling (2017 NEC) (IAEI Central)
All certifications (five 2-hour sessions)
Staff Notes: The five sessions include one session already presented February 9, for which retroactive approval is sought. The Committee can ignore the session listed for the year 2024. It will be submitted at the proper time.
ESIAC Recommendation: Recommend approval.
Committee Recommendation:

ER-3 Soares Grounding and Bonding (2017 NEC) (IAEI Central)
All certifications (five 2-hour sessions)
Staff Notes: The five sessions include two sessions presented on January 12 and March 9, for which retroactive approval is sought. The Committee can ignore the two sessions listed for the year 2024. They will be submitted at the proper time.
ESIAC Recommendation: Recommend approval
Committee Recommendation:

ER-4 Western Section IAEI Special Meeting (IAEI Western)
All certifications (18.5 hours)
Staff Notes: The submitter has made it clear that, despite the way he filled out the application, this two-and-a-half-day meeting is not a multisession course. If approved, it will receive one course number.
ESIAC Recommendation: Recommend approval.
Committee Recommendation:

Old Business

New Business

Adjourn

EDUCATION COMMITTEE MEETING
CONSENT AGENDA

Course Applications

EC-1 2021 IBC Accessibility and A117.1-17 (ICC)
All certifications (4 hours)

EC-2 2021 IBC Fire-Resistance-Rated Walls (ICC)
All certifications (4 hours)

EC-3 2021 IBC Means of Egress (ICC)
All certifications (4 hours)

EC-4 2021 IBC Occupancy Classification and Mixed Occupancies (ICC)
All certifications (4 hours)

EC-5 2021 IBC, IRC, IFC Update (ICC)
All certifications (4 hours)

EC-6 2021 IECC Update (ICC)
All certifications (2 hours)

EC-7 2021 Plumbing, Mechanical, and Gas Update (International Code Council)
All certifications (2 hours)

EC-8 An Overview of Changes from ACI 318-14 to ACI 318-19 (ICC)
All certifications (2 hours)

EC-9 Electric Vehicle Power Transfer Systems and the 2020 NEC Part 2 (Matthews Electrical Services)
All certifications (4 hours)

EC-10 Ever-Changing Structural Provisions of Our Building Codes: Wind (ICC)
All certifications (2 hours)

EC-11 Firestop Plan Review and Inspection (Northwest Ohio Fire Prevention Association)
All certifications (8 hours)

EC-12 Surfside, Florida Building Collapse and ACI 318 Requirements for Structural Concrete (ICC)
All certifications (4 hours)

EC-13 Understanding Emergency Responder Communication Enhancement Systems Codes and Technology (Koorsen Fire and Security)
All certifications (1 hour)

EC-14 BlazeMaster Fire Protection Installation Training (Lubrizol Advanced Materials)
All certifications (2 hours)

EC-15 FlowGuard Gold/Corzan Installation Training (Lubrizol Advanced Materials)
All certifications (2 hours)

EC-16 Updating Ohio's Codes for 2024 Round Table (Molnar)
All certifications (1 hour)
1 hour Code Administration

File Attachments for Item:

ER-1 2024 IBC, IRC, IFC Sneak Peak (ICC)

All certifications (4 hours)

Staff Notes: 2024 IBC and IFC not being considered for adoption at this time. 2024 IRC not yet in rule development process. Not recommended for approval.

Committee Recommendation:

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2024 IBC, IRC, IFC Sneak Peak

Course instructor: Jay Woodward / John Gibson

Course description: This fast-paced session will provide an introduction to a number of important code changes that are scheduled to be included in the 2024 editions of several International Codes. Key additions, revisions and modifications to the 2024 International Building Code® (IBC®), International Residential Code® (IRC®) and International Fire Code® (IFC®) will be presented in this early look at these three upcoming I-Code publications.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: May 3, 2023 / Tampa Bay, FL

Special Content:

Code Administration:_____
Existing Buildings: _____
Electrical Instruction: _____
Plumbing Instruction:_____

Conference Course: 2024 IBC, IRC, IFC Sneak Peak
Conference Name: ICC Spring Interchange
Conference location: Tampa Bay, FL

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2024 IBC, IFC and IRC Sneak Peek

Description

Overview of the key changes from the 2021 to the 2024 editions of the International Building Code (IBC), International Fire Code (IFC) and International Residential Code (IRC). Identifies changes in organization and code requirements and the applicability of these requirements to design, plan review and inspection. This course provides the attendees with an advanced look at some of the new and revised requirements that are contained in these three International Codes.

Goal

The goal of *2024 IBC, IFC and IRC Sneak Peek* is to familiarize building officials, fire officials, plans examiners, inspectors, design professionals, contractors, and others in the design and construction industry with many of the important changes in the 2024 editions of the IBC, IFC and IRC.

This publication is designed to assist those code users in identifying the specific code changes that have occurred and, more importantly, understanding the reason behind the change.

Objectives

Upon completion of this seminar, participants will be better able to:

- Identify the most significant differences between the 2021 and 2024 editions of the IBC, IFC and IRC.
- Identify whether the code change is an addition, deletion, modification or clarification.
- Identify the purpose and intent of the code changes.
- Identify the application of the new and revised design, plan review and inspection requirements.

Outline of Seminar **(4 hours = 240 minutes)**

1) Course overview (10 minutes)
   a) Introductions (5)
   b) Objectives (5)

2) International Building Code (75 minutes)
   a) Definitions (5)
   b) Building Planning (20)
   c) Fire Protection (20)
   d) Accessibility (10)
   e) Structural Provisions (15)
   f) Building Services (5)

3) International Fire Code (75 minutes)
   a) Definitions (10)
   b) General Safety (10)
   c) Building and Equipment Design (40)
   d) Special Occupancies and Operations (10)
   e) Hazardous Materials (5)

4) International Residential Code (75 minutes)
   a) Building Planning (30)
   b) Building Construction (35)
   c) Mechanical, Plumbing and Electrical (10)

5) Summary and Wrap-up (5 minutes)

Jay Woodward,
International Code Council

Jay is a Senior Staff Architect with ICC's Business and Product Development department and works out of the Lenexa, Kansas Distribution Center. His primary responsibility is the development of new ICC publications and instructing seminars. Among the publications he has authored or co-authored are the *Significant Changes* books on the IBC, IMC and A117.1 standard, and the recent ICC book *Firestopping, Joint Systems and Dampers*.

With over 30 years of experience in building design, construction, code enforcement and instruction, Jay's experience provides him with the ability to communicate effectively on issues of code application and design for code enforcement personnel as well as architects and designers. Jay has previously served as the secretariat for the ICC A117.1 standard committee, ICC's Energy Conservation Code and the *International Building Code's* Fire Safety Code Development committee.

John M. Gibson, Jr., M.C.P., C.B.O., C.P.C.A., C.F.M.

John is the Technical Manager/ Education and an Instructor for the International Code Council (ICC). A certified Master Code Professional and Certified Fire Marshal; he has forty- five (45) other certifications, including thirty-six (36) from the ICC. Having earned a B.S. in Engineering from the University of Delaware, he has also studied Architecture at Georgia Tech and completed courses in Emergency Management and Fire Prevention at the National Emergency Training Center.

Formerly the Director of the Department of Permits and Inspections for Frederick County Maryland, he is an ICC Honorary Member, has served on the ICC- Evaluations Services (ICC- ES) Board of Directors, the ICC Code Correlating Committee, the Board of Directors for BOCA International, Inc., Maryland's Governor's Smart Code Strategy Group, Chaired the ICC Board for International Professional Standards and is an Honorary Member and Past President of the Maryland Building Officials Association.

He currently teaches ICC administrative, building, residential, existing building, permit technician, property maintenance, zoning, green building, fire, wildland/urban interface, energy courses, and is a contract instructor at the Dept. of Homeland Security, United States Fire Administration, National Fire Academy, Emmitsburg, MD. He received the ICC Educator of the Year award in 2010.

2024 IBC, IRC and IFC Sneak Peek

1

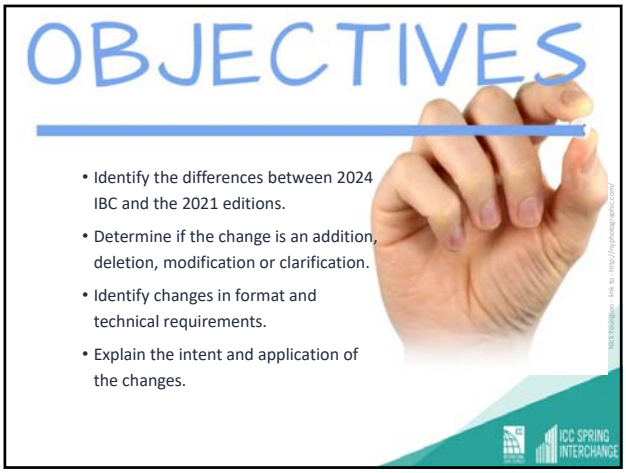
Education Sessions
Sponsored By

2

Identify changes between the 2021 and 2024 IBC, IRC and IFC

Be familiar with intent and application of a number of the latest code changes.

3



- Identify the differences between 2024 IBC and the 2021 editions.
- Determine if the change is an addition, deletion, modification or clarification.
- Identify changes in format and technical requirements.
- Explain the intent and application of the changes.

4

Part 1
International Building Code

5

104 Building Official Duties and Powers

- Provisions of Section 104 have been reformatted for consistency with other I-Codes
- In addition, approach for reviewing for code compliance significantly updated to reflect current manner that alternate materials, methods and designs are evaluated
- Four methods identified for determination of compliance:
  - Listed compliance
  - Technical assistance
  - Alternate materials, design and methods
  - Modifications

6

202 Definition—Limited or Physical Assistance

- Applicable to Group I-1 and R-4 occupancies, more clarity is provided for determining if Condition 2 designation is appropriate for group homes, assisted living facilities and other custodial care uses
- Category includes persons who may not independently recognize, respond or evacuate without limited verbal or physical assistance during an emergency situation
- Limited verbal assistance includes prompting, giving and repeating instructions
- Limited physical assistance includes help with transfer to walking aids or mobility devices and assistance with egress

7

202 Definition—High-Rise Building

- Special provisions, found primarily in Section 403, are mandated for buildings defined as "high-rise"
- Historically, such buildings are those with an occupied floor more than 75 feet above the lowest level of fire department vehicle access
- "High-rise" designation now also applies where occupiable roof is located above the 75-foot point
- Applicable concerns include:
  - Presence of occupants
  - Combustible furnishings
  - Difficulty of performing ground-based operations

8

304.1 Group B Occupancy Classification

- Electronic data processing has been modified to electronic data entry
  - Data entry is considered an activity performed in an office environment
  - Data processing is essentially automated work occurring in facilities typically accessed solely by maintenance personnel
    - More appropriately classified as Group F
- Lithium-ion and lithium metal battery testing, research and development activities newly addressed specifically and identified as Group B
  - Moderate-hazard classification is appropriate due to extensive protection features as established in IFC 1207, including:
    - Detection
    - Suppression
    - Explosion control

9

307.1.1, 414.1 Group H Occupancy Exemptions

- Provides for a more organized and comprehensive presentation of those conditions and materials that are exempt from:
  - Classification as a Group H occupancy, and
  - Needing to comply with any of general hazardous material regulations
- Replaces previous listing of exceptions in Section 307.1.1 and applicable notes to Tables 307.1(1) and 307.1(2)

TABLE 307.1.1 HAZARDOUS MATERIAL EXEMPTIONS[a]

Material Classification	Occupancy or Application	Exemption
Combustible fiber	Baled Cotton	Densely packed baled cotton shall not be classified as combustible fiber, provided that the bales comply with the packing requirements of ISO 8115
Corrosive	Building materials	The quantity of commonly used building materials that are classified as corrosive materials is not limited
	Personal and household products	The quantity of personal and household products that are classified as corrosive materials is not limited in retail displays, provided that the products are in original packaging.
	Retail and wholesale sales occupancies	The quantity of medicines, foodstuffs or consumer products, and cosmetics containing not more than 50 percent by volume of water-miscible liquids with the remainder of the solutions not being flammable, is not limited. To qualify for this allowance, such materials shall be packaged in individual containers not exceeding 1.3 gallons.

(continued)

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310.4 Group R Occupancy Classification

- In addition to several clarifications of various residential uses, the lodging house provisions have been revised.
- The scoping provisions for bed and breakfast establishments and similar lodging houses classified as a Group R-3 occupancy no longer mandate a maximum of 10 occupants
- In addition, there is no longer an occupant load limit required for construction of an owner-occupied lodging house under the *International Residential Code*
- The sole factor for lodging house classification that remains is the limit permitting no more than five guest rooms

11

411 Puzzle Rooms

- Puzzle rooms no longer required to comply with Section 411 as special amusement areas where the means of egress meets the fundamental requirements of Chapter 10
  - Unlocked
  - Readily available
  - Always available
- Previously, puzzle room exiting had to comply with one of three options:
  - Compliance with Chapter 10
  - Alternative design approved by building official
  - Exit system open and readily available upon activation by automatic fire alarm system, automatic sprinkler system, and a manual control at a constantly attended location

12

Table 509.1 Incidental Uses

- Sprinkler protection is now mandated in the following incidental use areas in ambulatory care facilities:
  - Storage rooms greater than 50 square feet
  - Waste and linen collection rooms with an aggregate volume of 8.67 cubic feet or greater
- Such rooms now require both the previously mandated 1-hour fire barrier and sprinkler protection
- Additional changes include lowering the following thresholds for inclusion as an incidental use for consistency with CMD federal standard:
  - Waste/linen collection rooms: Reduction from ≥ 10 cf to ≥ 8.67 cf
  - Storage rooms: Reduction from < 100 sf to < 50 sf

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Table 509.1 Incidental Uses

TABLE 509.1
INCIDENTAL USES

In Group I-2, laundry rooms over 100 square feet	1 hour and provide automatic sprinkler system
Group I-3 cells and Group I-2 patient rooms equipped with padded surfaces	1 hour and provide automatic sprinkler system
In Group I-2, physical plant maintenance shops	1 hour and provide automatic sprinkler system
In ambulatory care facilities or Group I-2 occupancies, waste and linen collection rooms with containers that have an aggregate volume of ~~10~~ 8.67 cubic feet or greater	1 hour and provide automatic sprinkler system
In other than ambulatory care facilities and Group I-2 occupancies, waste and linen collection rooms over 100 square feet	1 hour or provide automatic sprinkler system
In ambulatory care facilities or Group I-2 occupancies, storage rooms greater than ~~100~~ 50 square feet	1 hour and provide automatic sprinkler system
Electrical installations and transformers	See Sections 110.26 through 110.34 and Sections 450.8 through 450.48 of NFPA 70 for protection and separation requirements.

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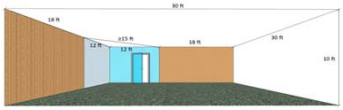
510.2 Horizontal Building Separation

- Where the horizontal building separation allowance (podium buildings) of Section 510 is applied, the restriction on occupant loads for the upper building has been eliminated
- Previously, the only Group A occupancies permitted above the podium level were those with an occupant load of less than 300
- In addition, where vertical offsets occur in the horizontal separation required between the upper and lower buildings, the offsets shall be constructed as for fire barriers

15

602.4.2 Exposed Mass Timber in Type IV-B Construction

- The allowable unprotected mass timber on the ceilings of Type IV-B buildings has been increased from 20% to 100%
  - Revisions are based on fire research conducted at the Research Institute of Sweden
  - Tests exhibited satisfactory performance in that no significant fire growth was observed and temperatures within the compartment decreased continuously until the end of the four-hour test
- The separation distance between unprotected mass timber elements is now only required for walls



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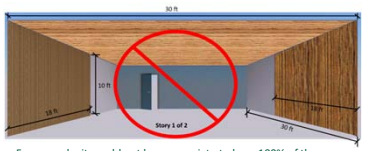
602.4.2 Exposed Mass Timber in Type IV-B Construction

- In addition, multiple-story floor areas are prohibited from being used to determine the allowable exposed mass timber in ceilings and walls in multi-story dwelling units and fire areas
  - Prohibition due to no testing of such conditions
- Each story to be evaluated on a story-by-story basis



For example, it would not be appropriate to have 100% of the ceiling and 60% of the walls (based on floor area) exposed on one of the two stories.

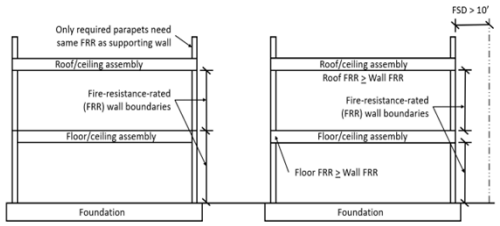
17

705.6 Exterior Wall Fire Rating Continuity

- The continuity requirements for the fire-resistance rating of exterior walls are now addressed for two conditions
- The required rating shall extend from the top of the foundation or floor/ceiling below to one of the following:
  - Underside of floor or roof sheathing , deck or slab above, or
  - Underside of floor/ceiling or roof/ceiling assembly having a fire-resistance rating ≥ the exterior wall, and the fire separation distance > 10 feet

18

705.6 Exterior Wall Fire Rating Continuity



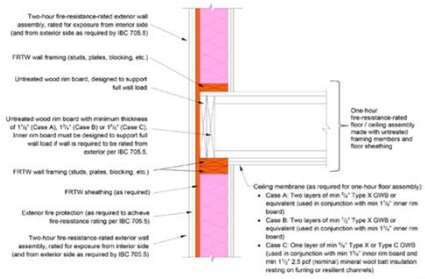
19

705.7.1 Exterior Wall/Floor Intersections in Type III Construction

- New provisions for load-bearing exterior walls in Type III construction clarify detailing where floors intersect the exterior wall in typical "platform" framing
- Fire-resistance rating of portion of floor assembly that supports exterior wall to be ≥ than the rating required for the exterior wall per Table 601
  - The rating provided by the portion of the floor assembly supporting and within the plane of the exterior wall is permitted to include the contribution of the ceiling membrane when considering exposure from fire to the inside
- Where wall is load-bearing, floor construction within plane of the exterior wall to be in accordance with requirements for interior building elements of Type III construction
  - Includes rim joists, rim boards and blocking

20

705.7.1 Exterior Wall/Floor Intersections in Type III Construction



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706.1.2, 706.2 Fire Walls—Deemed to Comply

- The use of NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls and Fire Barrier Walls*, was previously recognized as acceptable for dealing with structural stability requirement of IBC
- Fire walls now may be fully designed and constructed in accordance with NFPA 221, except where IBC addresses similar issues
  - For example, NFPA 221 does not contain any requirement for fire wall fire-resistance ratings. Therefore, provisions of IBC Section 706.4 will apply

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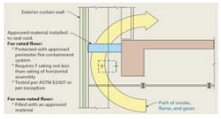
715.4, 715.5 Exterior Curtain Wall and Floor Intersections

- Voids created at the intersection of exterior curtain wall assemblies and floor or floor/ceiling assemblies are required to be filled or protected to prevent the interior spread of fire
  - Fire-resistance-rated floor or floor/ceiling assemblies: Protected
  - Nonfire-resistance-rated floor or floor/ceiling assemblies: Filled
- Three new exceptions now provided where such voids do not require protection or filling
  - Floors within a single dwelling unit
  - Floors and ramps within parking garages
  - Mezzanine floors



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1106.3 Parking for Groups R-2, R-3 and R-4

- Clarifies that accessible parking requirements for Group R-2, R-3 and R-4 occupancies to be based on "the greatest number" of either the 2% requirement or at least one space for each Accessible and Type A unit.
- Code previously was not clear how to apply these two provisions so often was interpreted as providing a choice to use one or the other.

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1106.3, 1106.7.1 Accessible Parking

- Group I-1 and R-1 (previous Item 2) removed from this section since they must provide accessible parking per Table 1106.2.
- Previous item 4 moved to location requirements of 1106.7.1. This expands the application to ***all occupancies*** and requires accessible parking be provided beneath the building if any parking is provided beneath the building.

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1108.6.1.1 Group R-1 Accessible Units

- New exception permits more limited bathing options where none of the Accessible units in the building contain bathtubs.
- Where NONE of the units within the building contain tubs, standard or alternate roll-in showers with seats are permitted.
- Maintains concept that people with disabilities should be treated the same as other occupants.
- A second exception allows transfer showers to be substituted for all but the minimum number of roll-in showers from Table 1108.6.1.1

26

1112.6 Tactile Room Identification Signs

- Provisions for tactile signage for interior and exterior signs identifying permanent rooms and spaces moved from Appendix Section E107.2.
  - Technical requirements for signage found in A117.1-17 Section 703
- Insertion into Chapter 11 results in no requirement for specific adoption
- Also clarifies that tactile signage only required "where provided"

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1110.4 Adult Changing Stations

- New provisions will require adult changing stations (or regulate them if they are just provided)
- They are required for:
  - Assembly and mercantile with aggregate of 6 or more male and female required water closets
  - Group B education facilities with aggregate of 12 or more male and female required water closets
  - Group E with an assembly room or space that requires an aggregate of 6 or more male and female water closets for that room
  - At highway rest stops and highway service plazas

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1110.4 Adult Changing Stations

- Required to be located in a single occupant toilet room or in a family or assisted use toilet room
- Are prohibited from requiring travel through a security checkpoint from the general separate-sex toilet and bathing rooms
- Located on accessible route within two stories and a maximum of 2,000 feet of travel
- The water closet and lavatory within the room can be included to satisfy the occupancy's overall fixture requirements

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Chapter 16 Structural Design Loads

- Updated loads
  - Snow
  - Wind
  - Rain
  - Seismic
  - Guards and handrails
- Tornado loads – new
  - RC III & IV
- Elevators & Escalators
  - Wind
  - Snow
  - Seismic

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Table 1705.3 Special Inspection – Rebar Welding

- Continuous special inspection
  - Reinforcement
    - Special moment frames
    - Boundary elements of special structural walls
    - Coupling beams
  - Reinforcement splices
  - Primary tension reinforcement in corbels

31

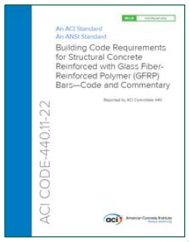
1807.2.5 Guards on Retaining Walls

- Where required
  - ≤ 36" of walking surfaces
  - > 30" vertically & ≤ 36" horizontally
  - Loads per 1607.9
- Height ≥ 42"
- Openings per 1015.4
- Exception
  - Not publicly accessible

32

Chapter 19 Concrete

- New GFRP standard
  - Low seismic areas
  - Highly corrosive environments
  - Supporting MRI equipment
- Seismic provisions reorganized
  - ACI 318 revisions removed
  - Supplemental provisions remain



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Chapter 21 Masonry

- Updated standards
  - Mortar requirements for adhered masonry veneers
  - GFRP for low seismic areas
  - Empirical design of Adobe Masonry references TMS 402-16

34

Chapter 22 Steel

- Updated standards
  - Structural stainless steel
  - CFS diaphragm panels
  - Steel decks
  - Industrial shelving & platforms
    - Stairs, ladders and guards
- Metal building systems
  - New definition
  - New provisions
  - New special inspections

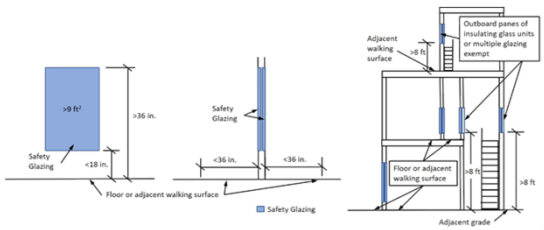
35

Chapter 23 Wood

- Updated standards
  - 2024 NDS
  - 2024 WFCM
- Revised FRTW provisions
  - FRT LVL
- Wind speeds updated
  - WSP wall sheathing
  - Rafter/truss uplift loads
- Connection fire protection
  - Type IV-A, IV-B & IV-C
- Wood shear walls and diaphragms
  - CLT and soil loads
- Hillside light-frame wood construction for seismic

36

2406.4.3 Glazing in Windows



- Required at windows where a person can fall
  - Out of a building
  - Into a building
  - Within the building

37

2902.1.2 Plumbing Fixture Calculations

- A methodology has been established to determine the required plumbing fixture count in many assembly uses where single-user or family/assisted toilet rooms are provided
- Number of fixtures in single user and family/assisted toilet rooms to be deducted proportionately from the required gender ratios of Table 2902.1

38

2902.1.2 Plumbing Fixture Calculations

EXAMPLE:

Given: A theater having 2000 occupants, the male water closet (WC) ratio is 1/125 and the female ratio is 1/65:

Design layout: Four single-user toilet facilities with the remainder of fixtures in multiple-user toilet facilities (separate sex).

Step 1: Determine minimum required number of male water closets, all located in a multiple-user toilet facility: 1000/125 = 8

Step 2: Determine minimum required number of female water closets, all located in a multiple-user toilet facility: 1000/65 = 15.4

Step 3: Add minimum required number of male and female water closets
Total = 23.4 WCs

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2902.1.2 Plumbing Fixture Calculations

Step 4: Proportionally reduce the number of water closets in the multiple-user toilet facilities (because of the presence of water closets located in single-user toilet facilities). In this example, each water closet in a single-user toilet facility allows for a reduction of 8/23.4 = 0.34 male water closets and 15.4/23.4 = 0.66 female water closets in the multiple-user toilet facilities.

Step 5: Therefore, four single-user toilet facilities, (4 x 0.34)= 1.36 male WC reduction and (4 x 0.66) = 2.64 female WC reduction.

Result: Thus, the multiple-user toilet facilities require a minimum of:

Male: 8 - 1.36 = 6.64 = 7 water closets

Female: 15.4 - 2.64 = 12.76 = 13 water closets

40

2902.3.6 Locking of Toilet Room Doors

- In a multi-user toilet room, the egress door is now permitted to be lockable from the interior side provided three conditions are met
- Egress door to be:
  - Lockable from inside of the toilet room only by authorized personnel by the use of a key or other approved means
  - Readily openable from the toilet room in accordance with Section 1010.2
  - Capable of being unlocked from outside the toilet room with a key or other approved means
- Allows for a safe area of refuge in the event of an emergency such as an active shooter

41

3001.2 Elevator Emergency Communication Systems

- Technical details of required elevator emergency communications system are no longer addressed in IBC as they are provided in reference standard
  - ASME—2019/CSA B44-19 *Safety Code for Elevators and Escalators*
- In addition, IBC now requires system to provide a means to enable authorized personnel to verify:
  - The presence of someone in car
  - That the person(s) is trapped
- Once an entrapment is verified, system to enable authorized personnel to:
  - Determine if assistance is needed
  - Communicate when help is on the way
    Communicate when help arrives on the site

42

3006.3 Smoke Protective Curtain Assemblies at Elevator Hoistways

- Where Section 3006.2 requires protection at an elevator hoistway door, a fifth method of protection utilizing a *smoke protective curtain assembly* has been established
- Defined as "a listed smoke and draft control curtain assembly consisting of a curtain coil, control unit, and perimeter sealing system"
- Curtain assembly to:
  - Comply with smoke and draft control requirements in Section 716.2.2.1.1 when tested per UL 1784 without an artificial bottom seal
  - Be equipped with a control unit listed to UL 864
  - Comply with Section 2.11.6.3 of ASME A17.1/CSA B44
  - Be installed and maintained in accordance with NFPA 105

43

3103 Temporary Structures

- New definitions
- Reduced loads
  - Snow
  - Wind
  - Flood
  - Seismic
  - Ice
  - Tsunami

- Installation and maintenance inspections
- Risk category for each structure
  - Based on 1.5 x height
  - Examples include stands supporting
    - Lights
    - Audio
    - Cameras

44

Appendix P Sleeping Lofts

- New Appendix P sets forth the scoping limitations and technical criteria for sleeping lofts that are provided within Group R dwelling units and sleeping units
- Provisions based in large part on IRC Appendix RQ regulating tiny houses
- The following lofts are exempt from compliance with App. P
  - Maximum depth of < 3 feet, or
  - Floor area < 35 square feet, or
  - Not provided with a permanent means of egress
- Scoping limitations include:
  - Floor area < 70 square feet, and
  - Ceiling height $\leq$ 7 feet for more than ½ of loft floor area

45

Appendix P Sleeping Lofts

- Special technical requirements/allowances include:
  - Means of egress
  - Guards
  - Smoke alarms
- Where permanent means of egress provided for sleeping lofts, the egress to comply with Chapter 10, except as modified in the following areas:
  - Stairway width, treads, risers and landings
  - Alternate tread devices height limit
  - Ship's ladder's height limit
  - Ladder's height limit, size, capacity and incline

46

ICC SPRING INTERCHANGE

Part 2
International Fire Code

47

202 Definition: Emergency Responder Communications Enhancement System

- Previously referred to as "Two-Way Emergency Responder Communications System"
- Required in all new buildings per Section 510 with exceptions
- Now recognizes that there are multiple types of solutions to address lack of communication coverage inside buildings for emergency responders
- Selection of proper solution and coordination of design, installation and maintenance is necessary for anyone operating on those frequencies.

48

202 Definition: Flammable Gas

- Category of flammable gas has been subdivided into two subcategories based on flammability characteristics
- Category 1A (historical definition) is default category, unless data shows compliance with Category IB
- Category 1B:
  - To meet flammability criteria for Category 1A, and
  - Is not pyrophoric
  - Is not chemically unstable
  - Meets one of two conditions addressing lower flammability limit or fundamental burning velocity
- Unless specifically specified, the term "flammable gas" includes both Category 1A and 1B

49

202 Definition: Occupancy Classification and Use

- IBC occupancy classifications have historically been located in IFC
- Occupancy classifications have been removed from list of definitions in Chapter 2 and relocated to new Section 203.
- Intended to improve user understanding and enhance correlation with the IBC
- New format is similar to that in the IBC and section numbering enhances ability to correlate provisions between the two codes

50

304.1.1, Appendix O Valet Trash and Recycling Collection in Group R-2

- Defined as service that removes trash/recycling materials placed outside of residential units for final collection
- Only permitted where approved by fire code official.
- Owner and collection service provider to comply with rules and limitations established by the jurisdiction
- Appendix O provide to address:
  - Containers cannot obstruct egress width
  - Containers must be liquid-tight and have a lid
  - Containers are limited in size (capacity and height)
  - Containers to be noncombustible or of limited flammability
  - Time of placement of containers outside of residential unit
  - Administrative controls

51

314.4 Indoor Vehicle Display

- Revisions made to address newer alternative fuels and power systems found in today's vehicles
- Clarifies that only ignition batteries need be disconnected
  - Not applicable to main batteries used for propulsion
- Limitations on fuel permitted in fuel tanks has been clarified and expanded to address:

• Class I, II &III liquid fuel	¼ tank or 5 gallons, whichever less
• LP-gas	¼ tank or 6.6 gallons, whichever less
• CNG	¼ tank or 630 cubic feet, whichever less
• Hydrogen	¼ tank or 2000 cubic feet, whichever less

52

319 Mobile Food Preparation Vehicles

- Entirety of Section 319 has been deleted and replaced with new provisions
- Most of previous specific provisions no longer in IFC, but are referenced in NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*
- Although standard contains most requirements for mobile cooking operations, some maintenance criteria is missing
- Maintenance provisions provided in Section 319, including:
  - Inspection and cleaning of exhaust hood
  - Maintenance of fire-extinguishing system
  - Maintenance of fuel gas systems, including annual leak test and inspection tag

  Manual operation of fire-extinguishing system

53

322 Powered Micromobility Devices

- Requirements added to regulate the use and recharging of powered micromobility devices
- Includes motorized bicycles and scooters, as well as other personal mobility devices powered by a lithium-ion or lithium metal battery (exempts those motor vehicles required to be registered with Department of Motor Vehicles
- Items regulated include:
  - General scoping
  - Prohibited locations
  - Battery chargers and equipment
  - Listing
  - Battery charging areas
  - Fire safety plan

54

403.10.6 Safety Plan for Lithium-ion Batteries

- Approved fire safety and evacuation plan in accordance with Section 404 now required for occupancies that involve activities for lithium-ion or lithium metal batteries
- Plan to be prepared and maintained where activity is:
  - Research and development
  - Testing
  - Manufacturing
  - Handling
  - Storage
  - Repair or serving of vehicles
- Fire safety and evacuation plan to include thermal runaway event mitigation measures

55

705.2.7 Rolling Fire Door Testing

- Rolling steel fire doors have a unique operation and require specific product training to ensure proper inspection
- Complex nature of tension release devices and automatic closing systems include multiple components that must work together for the door to operate properly
- Therefore, a specific section now mandates that such doors be inspected and tested by a trained fire door systems technician on an annual basis
  - To be done in accordance with NFPA 80

56

903.2 Sprinkler System Required – Lithium-ion and Lithium Metal Batteries

- Sprinkler systems are required in certain Group B, F-1, M and S-1 occupancies where these batteries are involved.
- Not limited to use in Energy Storage Systems as previously done.
- Addresses the unique fire hazard the batteries create and the potential for a thermal runaway fire.
- Sprinkler required for:
  - Group B: Laboratories, testing, research and development of batteries
  - Group F-1: Manufacture of batteries or vehicles, ESS or equipment using them
  - Group M: Storage
  - Group S-1: Storage or repair of vehicles powered by these batteries with Fire Area over 500 sq. ft.

57

903.2 Sprinkler System Required – Lithium-ion and Lithium Metal Batteries

- A number of other provisions have been added in other sections to better address the hazards of these types of batteries. This includes:
- Sprinkler system design is based upon fire tests to address specific hazard and arrangement. Does not use standard density requirements for the general occupancy area.
- New IFC Sections 320 and 322 which address Battery Storage and Powered Micromobility Devices respectively.
- IFC 322 does not require a sprinkler system but addresses other protection issues for storage, charging, location, planning, etc.

58

903.3.1.2 NFPA 13R Sprinkler Systems

- Increases the height of a Group R-2 occupancy building which can use an NFPA 13R sprinkler system.
- Changes from a 30-foot maximum height to the highest floor level to a maximum 45-foot height to the roof assembly.
- 45-foot height continues to be measured from lowest level of fire department vehicle access to the eave of highest pitched roof, intersection of highest roof and exterior wall, or top of highest parapet, whichever is greatest height.

59

903.3.1.2 NFPA 13R Sprinkler Systems

- Residential occupancies other than Group R-2 will continue to use the maximum 30-foot height limitation
- The revised provisions addressing Group R-2 provide greater consistency with the 2018 thresholds for 13R protection
  - Requirements also consistent with provisions addressing protection of attic spaces where a 13R sprinkler system is provided
- 2021 provisions were felt to be too restrictive for Group R-2 occupancies

60

907.2 Fire Alarm and Detection Systems

- Two new exceptions exempt manual fire alarm boxes and occupant notification system in smaller (<15,000 occupant) Group A-5 outdoor bleacher seating, and in temporary outdoor Group A-5 seating.
- Limitations for compliance include items such as:
  - Enclosed spaces under or attached; including whether it is allowed, size limits and separation.
  - Requirement for public address system with standby power in permanent facility
  - Use limit of 180 days for temporary facilities
  - Egress/evacuation plans per exceptions
- Exceptions based on Section 309 of ICC 300

61

907.2 Fire Alarm and Detection Systems

- New sections added to require detection systems in areas containing lithium-ion and lithium metal batteries.
- Similar to 903.2, requirements apply to Group B, F, M and S occupancies
- Requires an alarm system activated by air sampling-type smoke detection or radiant energy-sensing detection.
- Helps to prevent/limit fire or thermal runaway hazard by early detection of battery failures
- Since fires are almost impossible to extinguish, this helps detect problems to allow evacuation, or mitigation efforts prior to fire occurrence.

62

907.2.11.3 Smoke Alarms Near Cooking Appliances

- Modifies the location requirements applicable to smoke alarms due to changes in the listing standard.
- New testing standards help reduce nuisance alarms caused by cooking sources.
  - Align with NFPA 72 and UL 217
- Requires 10-foot horizontal separation to permanently installed cooking appliance, with exception permitting reduction to 6 feet to ensure detectors are installed where required by 907.2.11.1 or 907.2.11.2.
- Code previously used 20 feet, 10 feet or 6 feet, depending on alarm type.

63

915 Carbon Monoxide Detection

- Detection now required in all normally occupied occupancies where a carbon monoxide producing device is present.
- Previously was only required in Group I-1, I-2, I-4 and R occupancies and in classrooms of Group E occupancies.
- An exception exempts detection requirement in F, S and U occupancies that are not normally occupied.
- Requirements have also been substantially revised and reformatted.
- Relies on definition in Chapter 2 which helps limit scope to permanent CO sources or regularly used vehicles (vehicles in garage, propane forklifts, etc.) and not temporary or infrequent sources.

64

915 Carbon Monoxide Detection

- Reformatting helps clarify requirements and how each aspect is applied.
  - 915.1 addresses where CO detection is needed
  - 915.2 specifies where detection devices are placed for best protection
  - 915.3 through 915.5 deals with installation itself, including compliance with NFPA 72, detectors being hardwired, and interconnection
- System requirements depend on other features in the building. Can be stand-alone if no fire alarm system is present, done as part of a fire alarm system by adding detectors, or as a part of a security system that the occupant may already have (when done per NFPA 72).

65

1006.3.3, Table 1006.3.3 Egress from Stories and Occupiable Roofs

- New definition added to Chapter 2 for Occupiable Roof
- Roof is designed for human occupancy and access is for other than maintenance or repair
- Revisions throughout code from “occupied roof” to “occupiable roof” which will provide better consistency when applying provisions
- Egress is required from “occupiable roof” whether it is occupied or not

66

1010.2.4, 1010.2.5 Locks and Latches

- Adds four definitions (automatic flush bolt, constant latching bolt, dead bolt, and manual bolt)
- Reformats provisions and provides a table to clarify which type of latching bolt is permitted in various applications.
- Modifies existing "main door" exception to clarify it as being the main door into the building or tenant space and excludes secondary doors.
- Eliminates the occupant load limit of 10 for dwelling units or sleeping units to use night latch, dead bolt or security chain.
  - Now permitted for units permitted a single means of egress.

67

1010.2.14 Elevator Lobby Exit Access Doors

- Permits electronically locked exit access doors to serve as the means of egress from an elevator lobby.
- Eliminates the need for an elevator lobby to have direct access to an exit and allow the egress path to go through a tenant space which could normally be locked and unavailable.
- Requires eight conditions to be met, including:
  - NFPA 13 sprinkler system
  - Fire alarm system
  - Smoke detection system in lobby
  - Other occupants of floor to have access to two exits without travel through lobby
  - Two-way communication system within the lobby

68

1013.2 Low-level Exit Signs in Group R-1

- New exception eliminates the requirement for low-level exit signs in areas serving the guestrooms of Group R-1 occupancies when the building is sprinklered.
  - The exception will required either an NFPA 13 or 13R system throughout the building.
- Low-level exit signs would still be required in older buildings which are not sprinklered and may lack many other current safety features.
- These additional exit signs were not felt to be justified based on many improvements in the fire safety record of R-1 occupancies. This includes compartmentation, sprinklers, alarms and loss history.

69

1029.3 Egress Courts – Opening Protection

- New exception eliminates the egress court requirements for a fire-resistance-rated wall and protected openings when the occupants have multiple egress path options.
- With options, it is unlikely that both egress paths would be blocked.
- Conceptually similar to existing exception permitted for egress balconies in Section 1021.2.
- Walls with limited fire separation distance would still require protection based on those requirements, but not necessarily based on the egress court protection requirement.

70

1107 Existing Lithium-ion Energy Storage Systems

- A Failure Modes and Effects Analysis (FMEA) must be provided to the fire code official by the owner of an energy storage facility where:
  - ESS utilizes lithium-ion battery technology having capacities exceeding values in Table 1207.1.1, and
  - Installed prior to jurisdiction's adoption of the 2018 or later edition of the *International Fire Code*
- Fire code official to review and approve FMEA
- Provisions also address:
  - Early detection and notification of thermal runaway, and
  - Corrective action plan for any hazards identified in the analysis

71

2404 Prohibited Enclosures for Spray Application Operations

- Inflatable or portable enclosures for spray application of flammable finishes is now prohibited except in marina, dry dock and construction areas
- Where membrane structures are used, they must be designed, constructed, protected, operated and maintained in accordance with NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*

72

2404.3 Limited Finishing Workstation

- The use of a limited finishing workstation has been added to the IFC for spray finishing operations
- Defined by NFPA 33 as 'power-ventilated apparatus that is capable of confining the vapors, mists residues, dusts, or deposits that are generated by a limited spray application.
  - It is not considered or regulated as a spray booth or spray room
- Allowance for spraying space still available for jobs not exceeding 9 square feet
- In addition to other construction and safety requirements:
  - Ventilation to be provided by dedicated air supply system
  - Automatic fire-extinguishing system to be provided
  - Quantity of materials sprayed in an 8-hour period not to exceed 1 gallon

73

3106 Inflatable Amusement Devices

- Provisions have been added for bounce houses, water slides, climbing obstacles and other similar inflatable equipment
  - Not applicable to devices operated on private property where not open to the public
- Issues addressed include:
  - Designed, anchored, operated and maintained in accordance with manufacturer's instructions and ASTM F2374
  - Flame propagation
  - Electrical equipment and wiring
  - Portable generators
  - Portable fire extinguishers

74

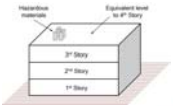
Chapter 41 Temporary Heating and Cooking Operations

- A chapter has been added to bring together code requirements for temporary heating and cooking operations found throughout the IFC, as well regulating some operations that were not previously addressed
- Although most of chapter provisions have existed for some time, several new items include:
  - Three new operational permits have been added:
    - Temporary heating or cooling in a tent
    - Temporary heating or cooling in wildfire risk areas
    - Temporary heating at a construction site
- Relocated provisions include:
  - Portable heating and cooking devices
    Temporary heating and cooking operations
    Mobile food preparation vehicles

75

5003.13 Rooftop Storage of Hazardous Materials

- A new section regulates the storage, use and handling of hazardous materials on roofs or canopies
  - Outdoor control area provisions of IFC Chapter 50 never intended to be applied to rooftops
- Issues address by Section 5003.13 include:
  - Occupancy classification
  - Maximum allowable quantity per rooftop or canopy
    - Adjustment to allowable quantities based on building's number of stories
- Applicable requirements for outdoor story to be met
- Weather protection to comply with IBC Section 414.6.1



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Appendix E Oxidizer Classification

- Information has been added to Appendix E to assist in correlating the oxidizer classifications in the IFC with those in the Globally Harmonized System
- Provides additional guidance in validating classifications of hazardous materials

Table E102.1.7.2
Oxidizer Comparison (IFC vs. GHS)

IFC Hazard Class	GHS Hazard Category
Oxidizer, Class 4	H271, Category 1
Oxidizer, Class 3	H271, Category 1
Oxidizer, Class 2	H272, Category 2
Oxidizer, Class 1	H272, Category 3

77

Part 3
International Residential Code

78

R104 Duties and Powers of the Building Official

- Section rewritten
- Detail to requirements added

79

R104 Duties and Powers of the Building Official

R104.1 General.
R104.2 Determination of compliance.
R104.2.1 Listed compliance.
R104.2.2 Technical assistance.
R104.2.2.1 Cost.
R104.2.2.2 Preparer qualifications.
R104.2.2.3 Content.
104.2.2.4 ~~R104.11.1~~ Tests.
104.2.3 ~~R104.11~~ Alternative materials, design and methods of construction and equipment.
104.2.3.1 Approval authority.
104.2.3.2 Application and disposition.
104.2.3.3 Compliance with code intent.
104.2.3.4 Equivalency criteria.
104.2.3.5 Tests.
104.2.3.6 Reports.
104.2.3.7 Peer review.
104.2.4 ~~R104.10~~ Modifications.
104.2.4.1 ~~R104.10.1~~ Flood hazard areas.
R104.3 ~~R104.2~~ Applications and permits.
R104.4 ~~R104.6~~ Right of entry.
R104.4.1 Warrant.
R104.5 Identification.
R104.6 ~~R104.3~~ Notices and orders.
R104.7 Official ~~Department~~ records.
R104.7.1 Approvals.
R104.7.2 Inspections.
R104.7.3 Code alternatives and modifications.
R104.7.4 Tests.
R104.7.5 Fees.
R104.8 Liability.
R104.8.1 Legal defense.
R104.9 Approved materials and equipment.
R104.9.1 Materials and equipment reuse.

80

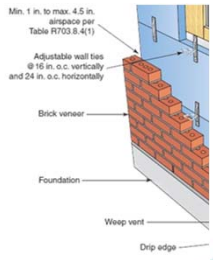
R202 Exterior Wall

- Above-grade wall
- Defines exterior boundaries of a building.
- Includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, gable end roof trusses, walls enclosing a mansard roof and basement walls with an average below-grade wall area < 50% of the total area of that enclosing side.

81

R202 Rainscreen System

- An assembly applied to the exterior side of an exterior wall which consists of, at minimum, two layers and a cavity between them sufficient for the passive removal of liquid water and water vapor.
- Adds alternative to a required airspace behind siding and veneer



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Chapter 3 Building Planning Reorganization

Section 301
Design Criteria

Section R302
Fire-resistant Construction

Section R303 ~~R316~~
Foam Plastic

Section R304 ~~R317~~
Protection Of Wood And Wood-based Products Against Decay

Section R305 ~~R318~~
Protection Against Subterranean Termites

Section R306 ~~R322~~
Flood-resistant Construction

Section R307 ~~R323~~
Storm Shelters

Section R308 ~~R319~~
Site Address

Section R309 ~~R313~~
Automatic Fire Sprinkler Systems

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Chapter 3 Reorganization

Section R310 ~~R314~~
Smoke Alarms

Section R311 ~~R315~~
Carbon Monoxide Alarms

Section R312 ~~R304~~
Minimum Room Areas

Section R313 ~~R305~~
Ceiling Height

Section R314 ~~R325~~
Mezzanines

Section R315 ~~R326~~
Habitable Attics

Section R316 ~~R309~~
Garages And Carports

Section R317 ~~R311~~
Means Of Egress

Section R318 ~~R310~~
Emergency Escape And Rescue Openings

Section R319 ~~R312~~
Guards And Window Fall Protection

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Chapter 3 Reorganization

Section R320
Accessibility

Section R321
Elevators And Platform Lifts

Section R322 ~~R308~~
Glazing

Section R323 ~~R303~~
Light, Ventilation And Heating

Section R324 ~~R306~~
Sanitation

Section R325 ~~R307~~
Toilet, Bath And Shower Spaces

Section R326 ~~R327~~
Swimming Pools, Spas And Hot Tubs

Section R327 ~~R324~~
Solar Energy Systems

Section R328
Energy Storage Systems

Section R329
Stationary Engine Generators

Section R330
Stationary Fuel Cell Power Systems

85

R301.2.3 Snow Loads

86

R301.2.3 Snow Loads

87

R302.1 Exterior walls

Fire Separation Distance

- Dwellings and townhouses on the same lot shall be assumed to have an imaginary lot line between them.
- Where a new dwelling or townhouse is to be erected on the same lot as an existing dwelling or townhouse, the location of the assumed imaginary line to the existing dwelling or townhouse must meet Section R302.

88

R302.2 Shared Accessory Rooms

- Separated from each individual dwelling unit per Table R302.3.2.
- Openings between the shared accessory room and dwelling unit comply with Section R302.3.2.1.
- Attachment of gypsum board complies with Table R702.3.5

SEPARATION	MATERIAL
From the dwelling units and attics	• ≥ 1/2-inch gypsum board or equivalent • Accessory room side wall
From habitable rooms above or below the accessory room	• ≥ 5/8-inch Type X gypsum board or equivalent
Structures supporting floor/ceiling assemblies used for separation required by this section	• ≥ 1/2-inch gypsum board or equivalent

89

R202, R314.3, R325.1, R326 Sleeping Lofts

SLEEPING LOFT.

- A space on an intermediate level or levels between the floor and ceiling of a story, open on one or more sides to the room in which the space is located, and in accordance with Section R326.

90

R202, R314.3, R325.1, R326 Sleeping Lofts

R326.1 Sleeping lofts.

- Where provided
- Sleeping lofts shall comply with Sections R326.2 through R326.5.
- Considered a portion of the story below.
- Such sleeping lofts shall not contribute to the number of stories as regulated by this code.

Exception:

Sleeping lofts need not comply with Section R326 when:

1. Maximum depth < 3 feet
2. Floor area < 35 square feet
3. Not provided with a permanent means of egress

91

R202, R314.3, R325.1, R326 Sleeping Lofts

R326.2 Sleeping loft limitations.

- Sleeping lofts shall comply with the following conditions:
  1. Floor area < 70 square feet (6.5 m).
  2. Ceiling height ≤ 7 feet (2134 mm) for > ½ of the sleeping loft floor area.
- Additional details for ceiling height, area, egress and stairway requirements.

92

R320.3 Care Facilities

R320.1 Dwelling units or sleeping units.

R320.2 Live/work units.

R320.3 Care facilities.

- Where permitted
- May use IRC for design
- Must be accessible per Chapter 11 of the *International Building Code* in the care facility portion of the building.

93

R321.1 Elevators and Hoistways

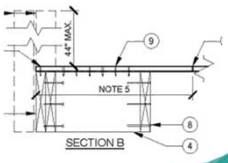
R321.1.1 Private Residence Elevators.

- The design, construction, and installation of private residence elevators installed within a residential unit or providing access to one individual dwelling unit shall conform to ASME A17.1/CSA B44, Section 5.3.

94

R502.11 Guard Attachment to Floor Framing

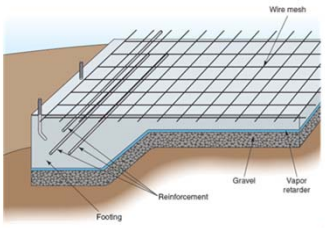
- Guards must transfer loads from the top of the railing to the floor or deck below.
- There hasn't been a prescriptive solution within the IRC.
- Both top and side mounting of guards may be done if sufficient material exists for fastener embedment.
- I-joists and trusses may not be used to fasten and brace guards unless specifically designed for the connection.



95

R506.2.3 Vapor Retarder

- Vapor retarder may be 6 mil polyethylene or 6 mil approved vapor retarder
- Returns to 2018 IRC requirement



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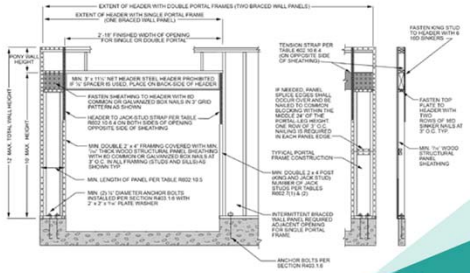
R602.10.6 Methods PFH, PFG and CS-PF

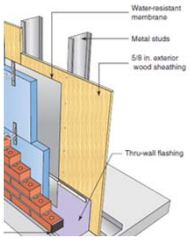
- Note added
  Header shall not extend over more than one opening.



97

R703.2 Water-resistive Barrier

- Provide a continuous WRB behind the exterior wall veneer and deck ledgers



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R703.2 Water-resistive Barrier

Exception:
WRB not required in unconditioned detached tool sheds, storage sheds, playhouses, and other similar accessory structures if:

1. Exterior wall covering is limited to siding that is attached direct to studs.
2. Exterior walls are uninsulated.
3. Interior side of exterior walls has no wall covering or wall finishes.

99

R905 Wind Resistance

- Roof cladding must have wind loads considered in high wind regions

100

R908.3 Roof Replacement

- Where roof sheathing is water soaked or damaged, it must be replaced, even when under ice barrier materials
- Where sheathing is undamaged, ice barrier materials may remain on the roof and covered by new underlayment

101

Appendix AJ Existing Buildings

- Appendix expanded
  - Now specifically addresses repairs, alterations and additions
  - Addresses habitable attics, stairs and relocated buildings
  - Considers structural loads

102

Appendix AZ Accessory Dwelling Units (ADUs)

- Appendix on ADUs is added
  - Contains limits to ADU location
  - Conditions where they may be built

103

Questions?

104

ICC SPRING INTERCHANGE

Thank you for Attending

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International Code Council is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

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Copyright Materials

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ICC SPRING INTERCHANGE

www.iccsafe.org/spring

#ICCSpringInterchange

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File Attachments for Item:

ER-2 One- and Two-Family Dwelling (2017 NEC) (IAEI Central)

All certifications (five 2-hour sessions)

Staff Notes: The five sessions include one session already presented February 9, for which retroactive approval is sought. The Committee can ignore the session listed for the year 2024. It will be submitted at the proper time.

ESIAC Recommendation: Recommend approval.

Committee Recommendation:

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Application for Continuing Education Course Approval

Provider Information:

Name: International Association of Electrical Inspectors (IAEI) Central Ohio division
Organization: International Association of Electrical Inspectors (IAEI) Central Ohio division
Address: 1081 Lewis Center Road Lewis Center, OH 43035
E-mail: lettherebelight110@yahoo.com Telephone: 937-763-6361
Website:
Conference Sponsor (if applicable) Conference Email:

Check here if Course Renewal: ☐ Prior course number (*i.e. BBS2018-429*)
Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 1 & 2 Family Dwelling (2017 NEC), Soares Grounding and bonding (2017 NEC).
Course instructor: Eric M. Klintworth PE; Matthew Ross; Chad Roberts
Course description: These classes will cover the 2017 NEC; via PowerPoint slides created by t of Electrical Inspectors (IAEI)

Instructional hours per session: 2 hours ea. Number of Sessions: 10; 13 if able to backd
Course Date(s) and Location: 1/12, 2/9, 3/9, 4/13, 5/11, 6/8, 9/14, 10/12, 11/9, & 12/14/2023; 1/11
1081 Lewis Center Road Lewis Center, OH 43035

Special Content:

Code Administration: ☐
Existing Buildings: ☐
Electrical Instruction: ☑
Plumbing Instruction: ☑

Conference Course:
Conference Name:
Conference location:

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐
Course Website:
Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ☐
Administrative Course, All Certifications: ☐

Application materials included:

☐ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

IAEI Central Ohio Division 2023-2024 syllabus

1. January 12, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 4 Grounding Electrical Services. Instructor, Matthew Ross.
2. February 9, 2023
    1. 1 & 2 Family (2017 NEC) (Vol I) Chapter 3. Instructor, Eric Klintworth.
3. March 9, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 5 Main bonding Jumpers and Services. Instructor, Matthew Ross.

The above classes have already been taught if it is possible to backdate to get credit for these classes, that would be great. If not, I understand. We have an attendance roster for verification.

4. April 13, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 6 Grounding Electrode Systems. Instructor, Matthew Ross.
5. May 11, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 4. Instructor, Eric Klintworth.
6. June 8, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 5. Instructor, Eric Klintworth.
7. September 14, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 7 Grounding Electorde Conductors. Instructor, Matthew Ross.
8. October 12, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 6. Instructor, Eric Klintworth.
9. November 9, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 8 Bonding Enclosures and Equipment. Instructor, Matthew Ross.
10. December 14, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 7. Instructor, Eric Klintworth.
11. January 11, 2024
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 9 Equipment Grounding Conductors. Instructor, Matthew Ross.
12. February 8, 2024
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 8. Instructor, Eric Klintworth.
13. March 14, 2024
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 10 Enclosure and Equipment Grounding. Instructor, Matthew Ross.

Eric M Klintworth, PE

638 Rockbridge Road, Westerville, Ohio 43081
klintworth@earthlink.net
Cell: 614–499–7056

Senior Electrical Engineer

A seasoned electrical engineer with in-depth experience in industrial control & automation, instrumentation, PLC, HMI, SCADA, and power distribution. Extensive hands-on startup, troubleshooting, and system level experience.

Core Competencies:

Industrial Control & Automation ▪ Instrumentation ▪ PLC ▪ HMI ▪ SCADA
Low & Medium Voltage Power ▪ Hazardous Locations ▪ Machine Safety
Field Startup & Commissioning ▪ Advanced Troubleshooting ▪ Expert Witness
VFD ▪ Servo Drives ▪ HVAC Controls ▪ Networking ▪ NEC ▪ UL 508a ▪ Lighting

Professional Experience

Hyperion Materials & Technologies/Diamond Innovations/Sandvik
Worthington, Ohio, 2014–present

Manufacturer of synthetic diamond and cubic boron nitride for industrial applications

Senior Electrical Controls Engineer, R&D

- Developed specialized control schemes and measurement techniques for high temperature, high pressure, pressing to facilitate new product development.
- Created Microsoft SQL Server database tables to automatically record process data from PLCs via Cimplicity.
- Customized imported hydraulic presses to meet specialized in-house needs via hardware, PLC, and HMI program additions.
- Led upgrade of cubic press controls and hydraulics to achieve unique multi-axis pressure control.

Consultant to Bricker & Eckler Attorneys, Columbus, Ohio, 2002–present

Troubleshooter and Technical Expert (occasional)

- Sort out performance issues with water and wastewater construction projects.
- Determine root causes and most economical remedies, working with owners, engineers, and contactors.
- Advise attorneys on technical matters.
- Prepare reports and serve as expert witness as needed.

Continued…

Eric M Klintworth, PE

Star Dynamics Corporation, Hilliard, Ohio, 2008–2014

Builder of advanced multi-target tracking radars and radar cross-section measurement systems

Staff Electrical Engineer

- Led design of AC and DC power distribution for mobile tracking radar system.
- Designed and programmed PLC-based radar system operator's console.
- Integrated digital motion controller with industrial servo drives for five-axis antenna characterization system.

LATA/Sharp and Associates, Westerville, Ohio, 1996–2008

Engineers and system integrators for environmental remediation, water, and wastewater systems

Senior Electrical Engineer

- Wrote and commissioned all PLC programs for radio-connected multi-site groundwater remediation system in Lansing, Michigan. Prepared and stamped electrical drawings for three system expansions.
- Replaced entire control and SCADA system at 3 Mgal/day municipal water treatment plant, Wadsworth, Ohio.
- Test/startup engineer and electrical SME at greenfield US Department of Energy DUF6 nuclear facility, Piketon, Ohio.
- Designed, programmed, and retrofitted PLC-based 21-site rural water distribution SCADA system, Erie County, Ohio.

Worthington Foods, Inc., Worthington, Ohio, 1993–1994

Producer of Morningstar Farms brand frozen and packaged vegetarian foods, now Kellogg's

Electrical Project Engineer

- Ferreted out and resolved complex power and control system deficiencies throughout the newly built Zanesville food plant.

Ormet Primary Aluminum Corporation, Hannibal, Ohio, 1987–1993

256 acre aluminum reduction plant producing 1.5M lb/day of sows and premium extrusion billets

Electrical Project Engineer

- Oversaw specification, procurement, and retrofitting of 13.8kV substations.
- Conceived and oversaw implementation of aluminum billet casting control system.

Education, Licensure, Professional Memberships

- BS in Electrical Engineering with Management Option, Ohio Northern University
- Registered Professional Engineer in Ohio, Michigan, Colorado, Arizona, & New Mexico
- Licensed Electrical Contractor in Ohio
- NFPA 70E Qualified Person
- IEEE Senior Member

Calculating the Load for a Two-Family Dwelling

- Trade practice is to supply the service equipment for a two-family dwelling through a common mast or through a common service lateral
- Where this is done, a duplex meter base is commonly installed
- A calculation must be performed to determine the minimum size of service-entrance or service-lateral conductors required to supply the common loads

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Calculation Methods of Two-Family Dwellings

- Standard calculation of both feeders and service-entrance or service-lateral conductors
- Optional calculation of feeders to individual dwelling units and standard calculation of service-entrance or service-lateral conductors
- Optional calculation under *NEC* 220.83
  - Two calculations are performed
  - Standard calculation under Article 220 Part III for two units, then for three units under Section 220.82
- Smaller of the two calculated loads can be used
- Applies only to service-entrance or service-lateral conductors

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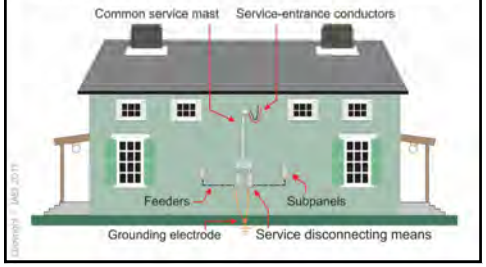
Service-Entrance Conductors - Two-Family Dwellings

For two-family dwellings with duplex meter base installations, a calculation must be performed to determine the minimum size of the overhead or underground service-entrance conductors required to supply the common loads



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Standard Load Calculation for Dwelling Unit

See **IAEI's One- and Two-Family Dwelling Electrical Systems** textbook (Volume I, Chapter 2) for complete details of load calculations and sample load calculation work sheets

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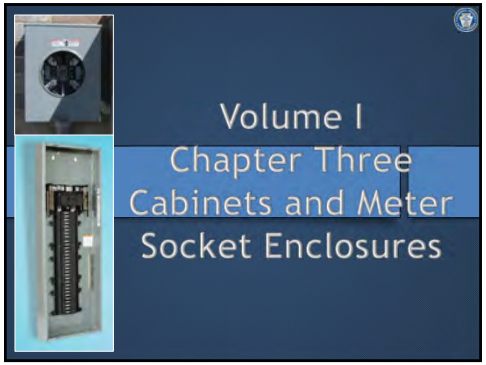

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Article 100: Definitions

- **Cabinet:** "An enclosure that is designed for either surface or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung."
- **Panelboard:** "A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front."

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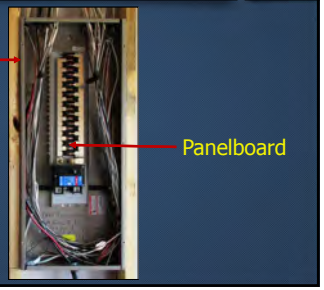
Article 100: Definitions



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312.2 Cabinets in Damp and Wet Locations

- Must be designed to prevent moisture or water from entering or accumulating within the cabinet or cutout box
- Shall be mounted so there is at least 6 mm (¼ in.) airspace between the enclosure and the wall or surface
- Enclosures installed in wet locations shall be weatherproof
- For enclosures in wet locations, raceways or cables entering above uninsulated live parts must use fittings listed for wet locations

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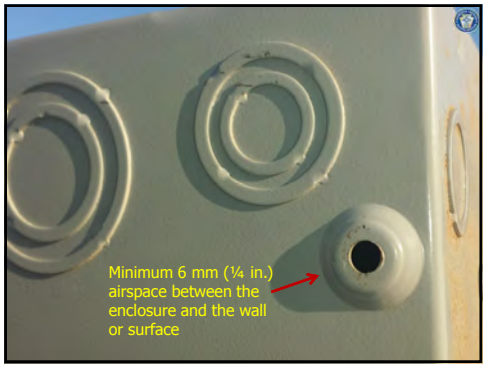

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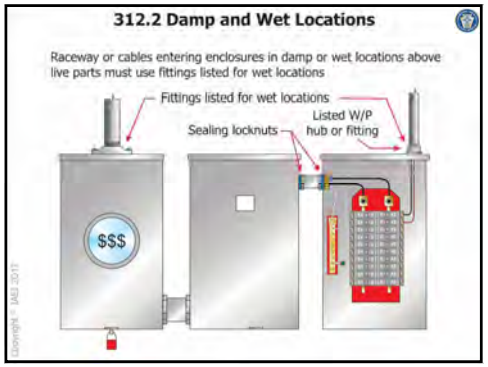

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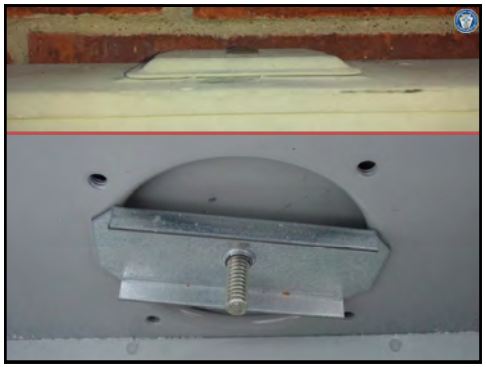

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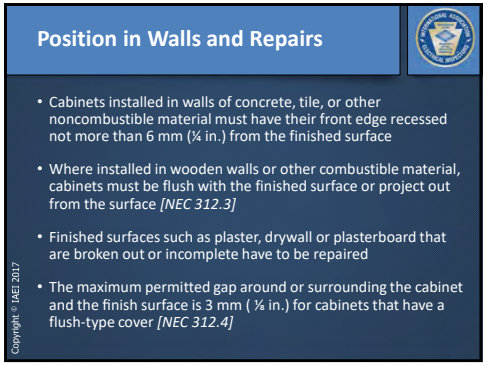

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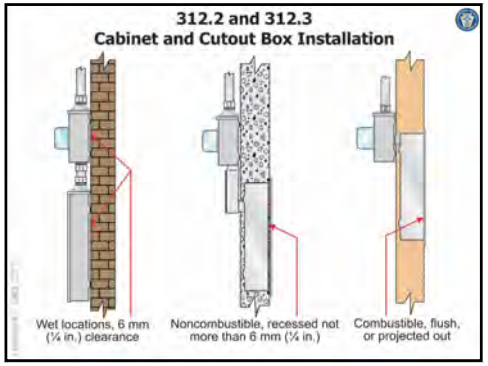

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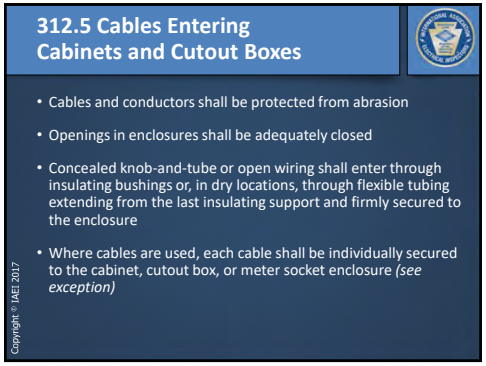

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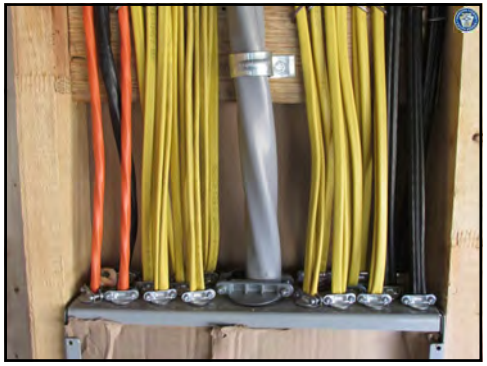

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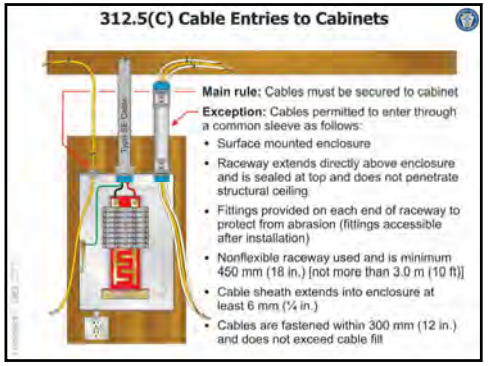

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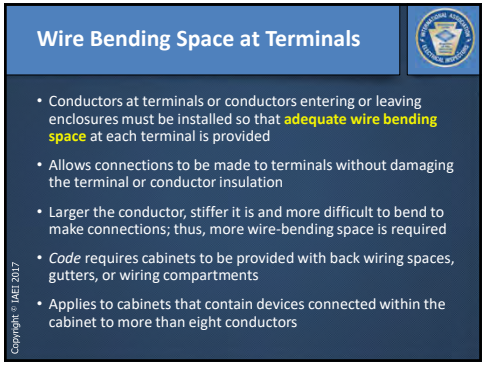

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408.55 Wire-Bending Space Within an Enclosure Containing a Panelboard

(A) Top and Bottom Wire-Bending Space
Minimum wire bending space per Table 312.6(B) for the largest conductor entering or leaving the enclosure
(4 exceptions to top and bottom space)

(B) Side Wire-Bending Space
Minimum wire bending space per Table 312.6(A) for the largest conductor entering or leaving the enclosure

(C) Back Wire-Bending Space
Minimum wire bending space per Table 312.6(A) based on the "one wire per terminal" column

The distance between the center of the rear entry and the nearest termination for the entering conductors shall not be less than the distance given in Table 312.6(B)

* Not all conductors shown
* Distances shown are based on 2/0 AWG as largest conductors entering or leaving the enclosure

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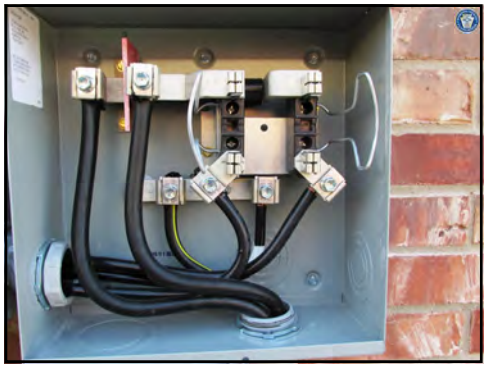

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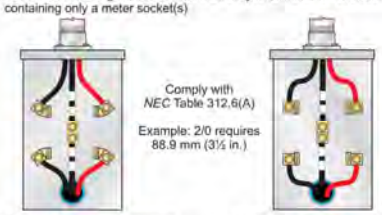
312.6(B)(2) Ex. No. 2: Meter Socket Enclosures

Conductors not larger than 350 kcmil and lay-in terminal for enclosure containing only a meter socket(s)



Comply with *NEC* Table 312.6(A)

Example: 2/0 requires 88.9 mm (3½ in.)

(a) Terminal is directed toward the opening in the enclosure and is within 45 degrees of directly facing enclosure wall

(b) Terminal directly faces wall and offset is not more than 50% of bending space in *NEC* Table 312.6(A)

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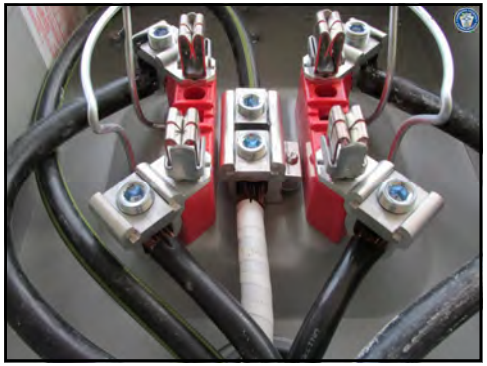

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Conductor Protection from Abrasion

- Insulated circuit conductors *(4 AWG or larger)* entering a raceway in a cabinet, pull box, junction box, or auxiliary gutter, required to be protected by an identified fitting providing a smoothly rounded insulating surface
- Fittings used for this purpose typically are an insulated conduit bushing *(Code permits alternatives such as a metal fitting with an insulated throat or a nonmetallic terminal adaptor)*
- Conduit bushings made wholly of insulating material are not permitted to be used to secure a raceway to an enclosure
- Listed metal locknut would need to be used in conjunction with an insulating bushing
- See *NEC* 312.6(C), 300.4(G)

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312.6(C) Protect Conductors from Abrasion

Insulated circuit conductors *(4 AWG or larger)* entering a raceway in a cabinet, pull box, junction box, or auxiliary gutter, required to be protected by an identified fitting providing a smoothly rounded insulating surface

Threaded hubs or bosses that are integral part of cabinet, box, enclosure or raceway

Insulating bushings providing a smoothly rounded insulating surface with conduit connected with locknuts

Applies to insulated circuit conductors in sizes 4 AWG or larger

Insulating bushings alone not permitted to connect conduit to enclosure

**See NEC 300.4(G)*

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Wire Space in Enclosures

- Cabinets and meter socket enclosures are required to have **sufficient space** to accommodate all installed conductors
- Cabinet enclosures for switches or overcurrent devices are generally **not permitted to be used as junction boxes**, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices ***(unless adequate space is provided)***
- Conductors not permitted to fill the wiring space at any cross section to more than **40%** of the cross-sectional area of the gutter space in the enclosure
- Where conductors are **spliced** in these switch or overcurrent device enclosures, the conductors, splices, and taps cannot fill the wiring space at any cross section to more than **75%** of the cross-sectional area of the space

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Wire Space in Enclosures *(cont.)*

- Where **feed-through conductors** are present, a **warning label** complying with NEC 110.21(B) is required to be applied to the enclosure identifying the closest disconnecting means for these feed-through conductors
- See *NEC* 312.8

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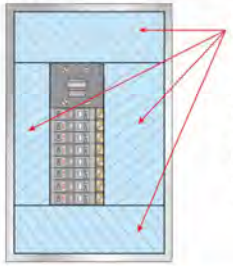
312.8 Enclosures for Overcurrent Devices

The wiring space of enclosures for switches or overcurrent devices is permitted to contain feed-through, splices, or tapped conductors where all of the following conditions are met:



Conductors cannot fill wiring space to more than 40%

Where splices or taps are made they cannot take up more than 75% at any cross section

Warning label complying with 110.21(B) applied to enclosure that identifies the closest disconnecting means for any feed-through conductors

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Mounting and Location of Switches and Overcurrent Devices

- Switches and circuit breakers of the externally operable type must be mounted in an enclosure listed for the intended use *[404.3(A)]*
- Minimum wire bending space at terminals and minimum gutter space must be provided in switch enclosures *[312.6]*
- Where installed in any damp or wet location or outside a building, a switch or circuit breaker is required to be enclosed in a weatherproof enclosure or cabinet *[404.4(A)]*
- General-use and motor-circuit switches and circuit breakers, where mounted in an enclosure, must clearly indicate whether they are in the open "off" or closed "on" position *[404.7]*

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Mounting and Location of Switches and Overcurrent Devices *(cont.)*

- Where switch or circuit breaker handles are operated vertically rather than rotationally or horizontally, the "up" position of the handle must be in the "on" position *[404.7, 240.81]*
- All switches and circuit breakers that are used as switches must be located so they can be operated from a readily accessible location *[404.8(A)]*
- All switches and circuit breakers must be installed so the **center of the grip of their operating handles**, when in their highest position, will not be more than **2.0 m (6 ft 7 in.)** above the surface of the floor or other working platform [404.8(A), 240.24(A)]

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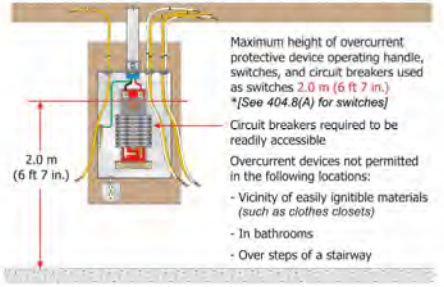
240.24 Accessibility and Location of Overcurrent Devices



Maximum height of overcurrent protective device operating handle, switches, and circuit breakers used as switches 2.0 m (6 ft 7 in.)
**[See 404.8(A) for switches]*

Circuit breakers required to be readily accessible

Overcurrent devices not permitted in the following locations:

- Vicinity of easily ignitible materials *(such as clothes closets)*
- In bathrooms
- Over steps of a stairway

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408.4(A) Circuit Directory or Circuit Identification

All panelboard circuits and any circuit modifications are required to be legibly identified as to its clear, evident, and specific purpose or use

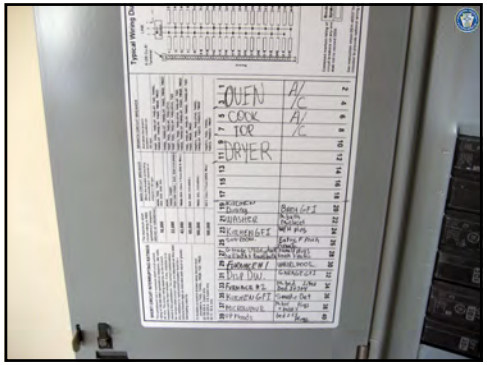
Circuit directory required to be located on the face or inside the panel doors

The circuit identification shall have an approved degree of detail to distinguish each circuit from all others

Spare positions containing unused overcurrent devices or switches required to be marked accordingly

Circuits shall not be identified in a manner that depends on transient conditions of occupancy

169



170

408.3(A)(2) Barriers at Service Panelboards

Barriers required in all service panelboards, switchboards, and switchgear such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations

Courtesy of Schneider Electric

Exception: *This requirement shall not apply to service panelboards with provisions for more than one service disconnect within a single enclosure as permitted in 408.36, Exceptions No. 1, 2, and 3*

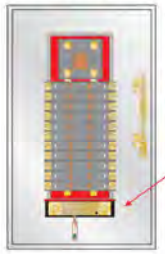
171

Main Bonding Jumper

- Where a panelboard is used as service equipment it must be provided with a **main bonding jumper**
- Generally, the *main bonding jumper* is a bus, strap, or screw provided by the manufacturer, and under this condition, it can be installed without a sizing requirement in the field
- It is placed within the panelboard and is used for connecting the grounded (neutral) service conductor on its supply side to the metallic frame of the panelboard
- See *NEC* 250.28, 408.3(C)

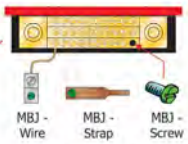
172

408.3(C) Panelboard as Service Equipment



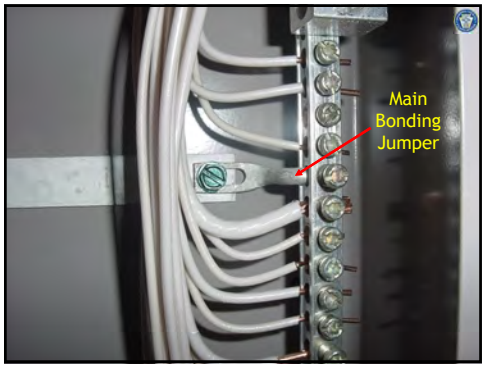
Where panelboard is used as service equipment, it must be provided with a main bonding jumper

Main bonding jumper is used to bond grounded conductor to enclosure on supply side



Service equipment must be marked and identified as "Suitable for Use as Service Equipment"

173



174

408.36 Overcurrent Protection for Panelboards

- Generally, a panelboard is required to be protected by an overcurrent protective device having a rating not greater than that of the panelboard
- This overcurrent protective device to be located within or at any point on the supply side of the panelboard
  - **Ex. No. 1**: Individual protection not required for a panelboard used as service equipment with multiple disconnecting means *[up to six means of disconnect(230.71)]*
  - Panelboards protected in this manner shall not supply a second bus structure within the same panelboard

(cont. on next slide)

175

408.36 Overcurrent Protection for Panelboards *(cont.)*

- Generally, a panelboard is required to be protected by an overcurrent protective device having a rating not greater than that of the panelboard
- This overcurrent protective device to be located within or at any point on the supply side of the panelboard
  - **Ex. No. 2:** Individual protection not required for a panelboard protected by main on its supply side *(two main circuit breakers or two sets of fuses)*
  - A panelboard employing this exception shall not contain more than 42 overcurrent devices

(cont. on next slide)

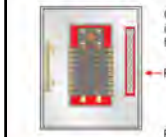
176

408.36 Overcurrent Protection for Panelboards *(cont.)*

- Generally, a panelboard is required to be protected by an overcurrent protective device having a rating not greater than that of the panelboard
- This overcurrent protective device to be located within or at any point on the supply side of the panelboard
  - **Ex. No. 3**: For existing panelboards, individual protection not required for a panelboard used as service equipment for an individual residential occupancy

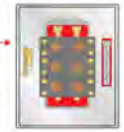
177

408.36 Overcurrent Protection for Panelboards

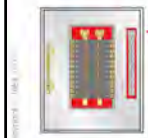


Generally, overcurrent protection for panelboards is required within or at any point on the supply side feeder for the panelboard *(with 3 exceptions)*

Panelboard with main in same cabinet



Panelboard with up to six means of disconnect per 408.36, Ex. No 1



"Main Lug Only" panelboard *(with main at supply side of feeder)* [408.36, Ex. No. 2]

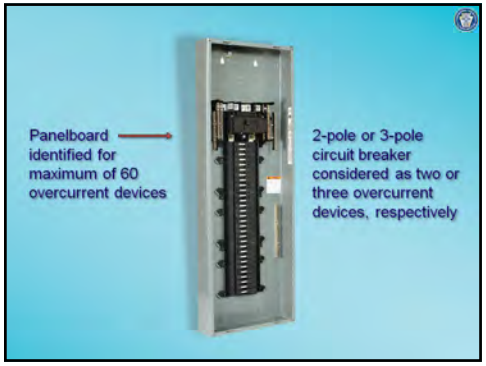
For existing panelboards, individual protection shall not be required for a panelboard used as service equipment for an individual residential occupancy [408.36, Ex. No. 3]

178

408.36 Overcurrent Protection for Panelboards *(cont.)*

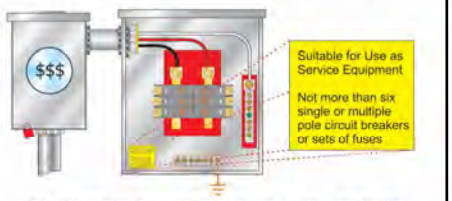
- Generally, panelboards are no longer limited to a maximum of 42 overcurrent devices per panelboard
  - *See 408.36, Ex. No. 2*
- Number of overcurrent devices per panelboard limited only by listing and manufacturer's specifications

179



180

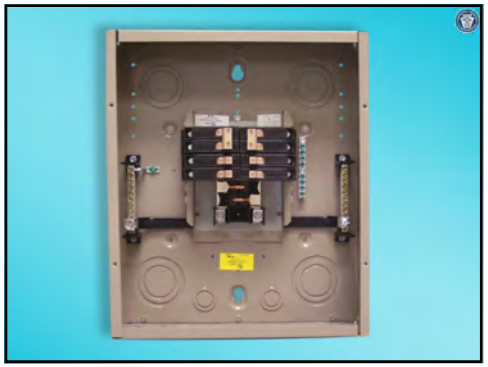
408.36 Ex. No. 1 Overcurrent Protection



Individual protection is not required for a panelboard used as service equipment with multiple disconnecting means in accordance with *NEC* 230.71

Panelboards protected by up to six means of disconnect shall not supply a second bus structure within the same panelboard assembly *(no split-bus panelboards)* (*NEC* 408.36 Ex. No. 1)

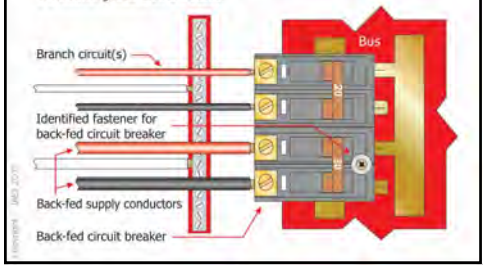
181



182

408.36(D) Back-Fed Devices

Overcurrent protection devices that are backfed and used to terminate field-installed ungrounded supply conductors must be secured in place by an additional fastener that requires other than a pull to release the device from the mounting means on the busbar



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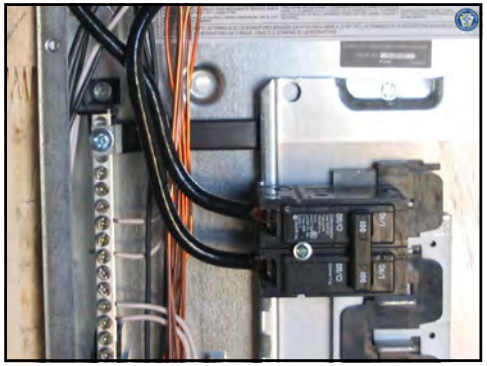
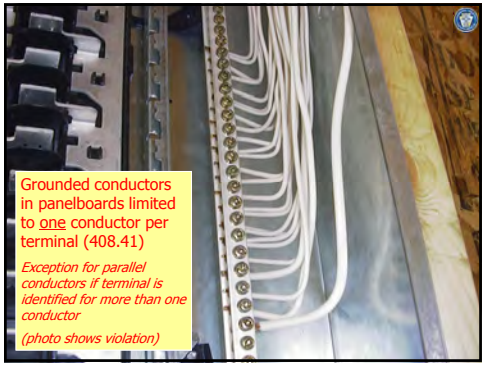


184

Grounded Conductors in Panelboards

- Each grounded (neutral) conductor must terminate in an **individual terminal** that is not to be used to terminate another neutral conductor
- Exception will allow more than one grounded conductor to terminate under one termination point where parallel conductors are installed, as long as they terminate in a terminal identified for more than one conductor
- See *NEC* 110.14; 408.41

185



186

408.40 Grounding of Panelboards

- Metal panelboard cabinets and panelboard frames must be:
  - In physical contact with each other
  - Connected to an equipment grounding conductor
- Where the panelboard is used with nonmetallic raceway or cable or where separate equipment grounding conductors are provided, a terminal bar for the equipment grounding conductors shall be secured inside the cabinet
- Terminal bar must be bonded to the cabinet and panelboard frame *(if of metal)* otherwise it shall be connected to the equipment grounding conductor that is run with the conductors feeding the panelboard
- *Exception for isolated equipment grounding conductor*

187

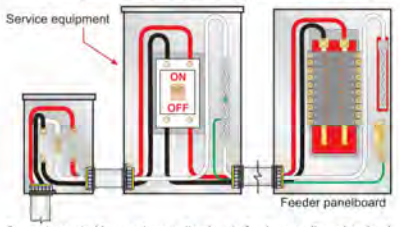
408.40 Grounding of Panelboards *(cont.)*

- Equipment grounding conductors are not be connected to a terminal bar provided for **grounded conductors** or **neutral conductors** unless…
- Terminal bar is:
  - **identified for the purpose**
  - located where interconnection between equipment grounding conductors and grounded circuit conductors is permitted or required by Article 250

188

408.40 Grounding of Panelboards

Feeder panelboard in compliance with *NEC* 408.36 Ex. No. 2

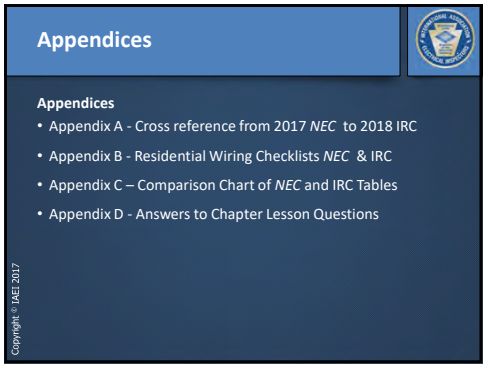


Separate neutral bus and grounding bus in feeder panelboard on load side of service

Equipment grounding terminal bar required in feeder panelboard

Feeder panelboard constructed or wired in this manner shall not contain more than 42 overcurrent devices

189


Appendices
Appendices
• Appendix A - Cross reference from 2017 NEC to 2018 IRC
• Appendix B - Residential Wiring Checklists NEC & IRC
• Appendix C – Comparison Chart of NEC and IRC Tables
• Appendix D - Answers to Chapter Lesson Questions
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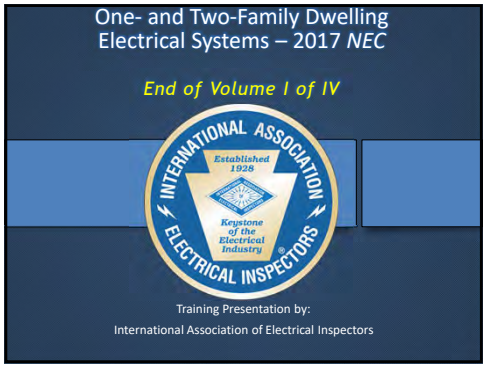
One- and Two-Family Dwelling
Electrical Systems – 2017 NEC
End of Volume I of IV
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Established 1928
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One- and Two-Family Dwelling Electrical Systems – 2017 *NEC*

Volume II of IV

Training Presentation by:
International Association of Electrical Inspectors

1

One- and Two-Family Dwelling Electrical Systems – 2017 *NEC*

- Presentation based on IAEI's *One- and Two-Family Dwelling Electrical Systems* , 10th edition textbook
- This textbook is based on the requirements contained the **2017 *NEC*** and the **2018 *IRC***

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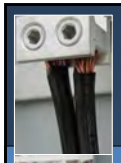


Volume II Chapter Four

Installation and Inspection of Services

4

5

General Requirements for Services

- A building or other structure is generally required to be served by only one service [*NEC* 230.2]
- Service conductors supplying a building or structure shall not pass through the interior of another building or structure [*NEC* 230.3]
- Conductors other than service conductors are not permitted in the same raceway or cable with the service conductors [*NEC* 230.7]
- Service raceways entering buildings from an underground distribution system required to be sealed with a material identified for the use [*NEC* 230.8]

6

Article 100: Definitions

- **Premises Wiring (System):** "Interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all their associated hardware, fittings, and wiring devices, both permanently and temporarily installed. This includes (a) wiring from the service point or power source to the outlets or (b) wiring from and including the power source to the outlets where there is no service point.
- Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, motor control centers, and similar equipment."
  - **Informational Note:** Power sources include, but are not limited to, interconnected or stand-alone batteries, solar photovoltaic systems, other distributed generation systems, or generators.

7

Article 100: Definitions

- **Service:** "The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served."
- **Service Cable:** "Service conductors made up in the form of a cable."
- **Service Conductors:** "The conductors from the service point to the service disconnecting means."

8

Article 100: Definitions

- **Service Conductors, Overhead:** "The overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure."
- **Service Conductors, Underground:** "The underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall."
  - **Informational Note:** Where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building.

9

Article 100: Definitions

- **Service Drop:** "The overhead conductors between the utility electric supply system and the service point."
- **Service-Entrance Conductors, Overhead System:** "The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop or overhead service conductors."

10

Article 100: Definitions

- **Service-Entrance Conductors, Underground System:** "The service conductors between the terminals of the service equipment and the point of connection to the service lateral or underground service conductors.
  - **Informational Note:** Where service equipment is located outside the building walls, there may be no service-entrance conductors or they may be entirely outside the building.
- **Service Equipment:** "The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply."

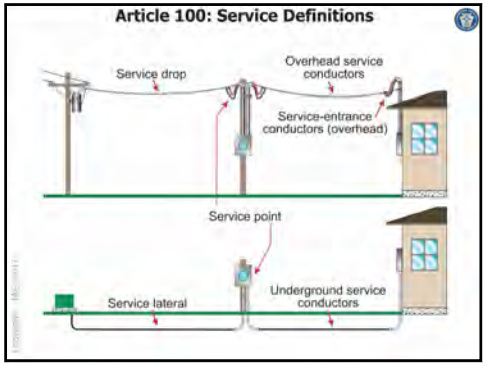
11

Article 100: Definitions

- **Service Lateral:** "The underground conductors between the utility electric supply system and the service point."
- **Service Point:** "The point of connection between the facilities of the serving utility and the premises wiring."
  - **Informational Note:** The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service.

12

Article 100: Service Definitions



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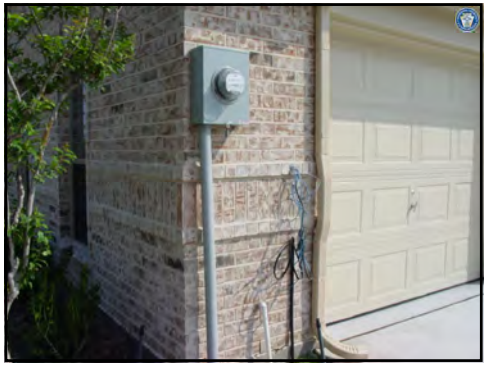

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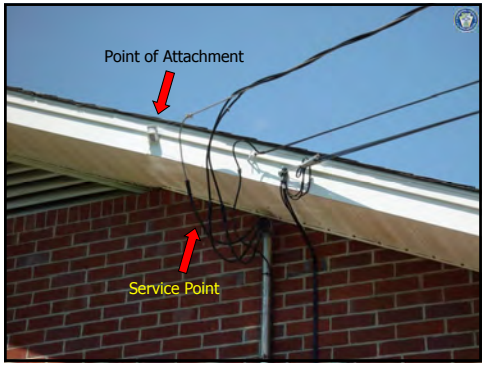


15

Clearances on Buildings

- The *Code* requires **minimum clearances for service conductors installed as open conductors** *(such as duplex or triplex service drops or multiconductor cables)* that do not have an overall outer jacket from building openings and other items such as:
  - Porches
  - Balconies
  - Ladders
  - Stairs
- Does not restrict the installation of a multiconductor cable assembly that has an overall outer jacket, such as Type SE
- See *NEC* 230.9

16

Clearances on Buildings *(cont.)*

- Open service conductors *(including the drip loop)* cannot be installed any closer than **900 mm (3 ft)** from the sides or bottom of any window that is designed to be opened
- This **900 mm (3 ft)** clearance required from:
  - Doors
  - Porches
  - Balconies
  - Ladders
  - Stairs
  - Fire escapes
  - Other similar locations

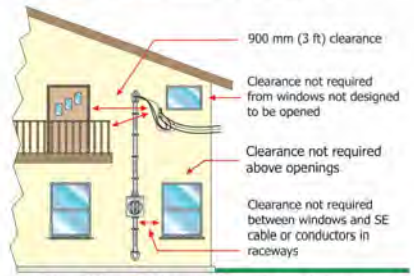
17

Clearances on Buildings *(cont.)*

- This **900 mm (3 ft)** clearance is intended to keep open service conductors at least **"reach distance"** from building openings or platforms
- Some forms of service conductors are **not required to maintain this 900 mm (3 ft)** such as:
  - Service conductors installed **above the top level of a window**
  - Service conductors in the form of service-entrance cable, Type SE or SER
  - Service conductors installed in a raceway

18

230.9 Clearance on Buildings



Minimum 900 mm (3 ft) clearance from windows designed to be opened, doors, porches, balconies, ladders, fire escapes, etc.

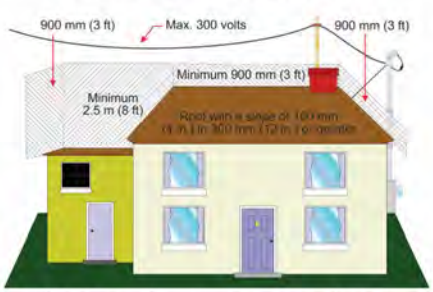
19

Service Drop Clearances Above Roofs

- General rule for clearances requires service drops to have a minimum vertical clearance of not less than **2.5 m (8 ft)** where they pass over a roof
- This **2.5 m (8 ft)** vertical clearance must generally be maintained for a distance of **900 mm (3 ft)** in all directions from the edge of the roof
- Five exceptions to this general rule
- See *NEC* 230.24(A) and (B)

20

230.24(A) Clearances Above Roofs



Vertical clearances for service conductors above roofs required

21

22

230.29 Supports Over Buildings

Metal support structures supporting overhead service conductors passing over a roof required to be bonded to grounded overhead service conductor

23

Service Drop Clearances Above Roofs *(cont.)*

- Service drops to have a minimum vertical clearance of not less than **2.5 m (8 ft)** above roof *(with exceptions)*
  - Reduction of the service-drop clearance to **900 mm (3 ft)** when the voltage between the service-drop conductors is not over **300 volts** and the roof has a slope of **100 mm (4 in.)** in **300 mm (12 in.)** or greater
- See 230.24(A) Ex. No. 2

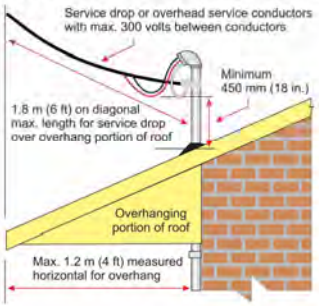
24

Service Drop Clearances Above Roofs *(cont.)*

- Service drops to have a minimum vertical clearance of not less than **2.5 m (8 ft)** above roof *(with exceptions)*
  - Reduction in clearance of the service-drop conductors to **450 mm (18 in.)** above the roof where:
    - Voltage between conductors does not exceed **300 volts**
    - Service drop passes over only the overhanging portion of the roof, and not more than **1.8 m (6 ft)** of service-drop conductor passes diagonally over the roof overhang
    - Service drop does not pass over an overhang that extends more than **1.2 m (4 ft)** horizontally from the structure
    - Secured to an electric service mast (through-the-roof) raceway or other approved support means
- See 230.24(A) Ex. No. 3

25

230.24(A) Ex. No. 3 - Clearances Above Roofs

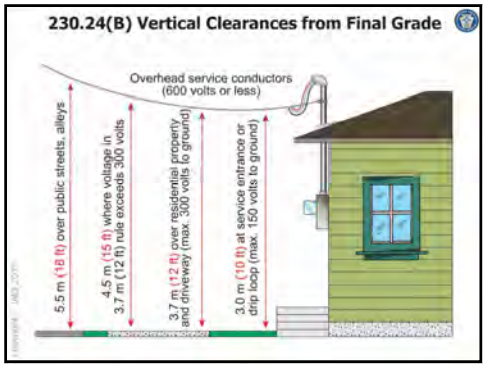


26

230.24(B) Vertical Clearances Above Final Grade

- Vertical clearances for service drops and overhead service conductors passing above finished grade or ground level vary depending on the voltage involved and the condition
- Vertical clearance must be maintained at the minimum distances described in the Article 230
- *See next slide*

27

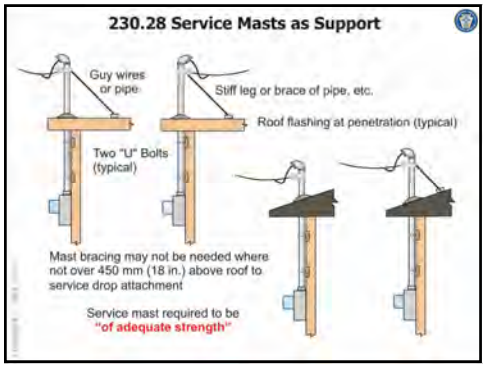


28

230.28 Service Mast as Support

- Service masts used as support of service drops must be **"of adequate strength"** to withstand safely the weight imposed by service drop *(or be supported by braces or guy wires)*
- The *Code* does not mandate minimum size of conduit permitted for a service mast or the use of additional support such as guy wires
- Interpretation of **"of adequate strength"** determined by AHJ
- Many serving utility companies provide a set of regulations that detail what is required for the service mast to which a service drop is to be attached
- By electric utility company regulations or local ordinances often require a **metric designator 53 (2 in.)** or larger steel galvanized **rigid metal conduit** to be used for an electric service mast

29



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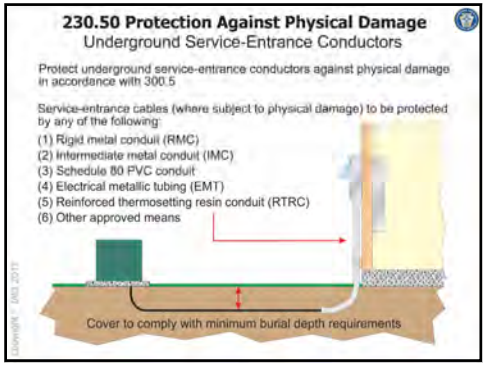

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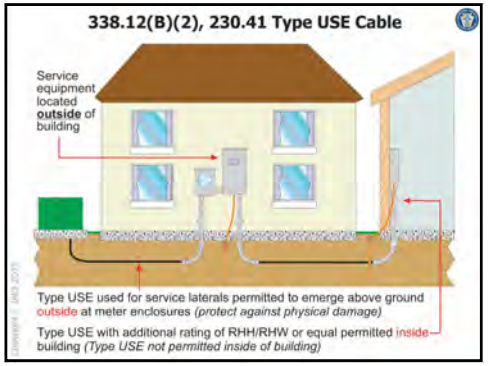


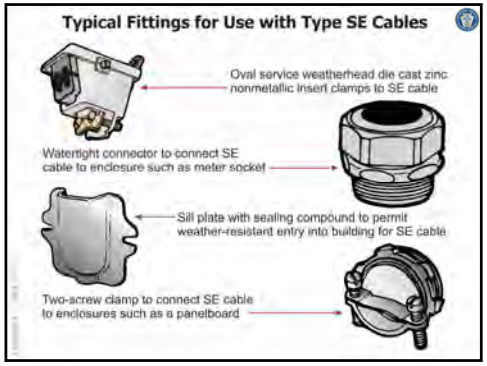
32

Service-Entrance Cable Installation

- Type SE cable can be used for services and is often used in older, existing dwelling units *(See NEC Article 338)*
- Several **fittings** are made to facilitate the installation of Type SE cables for services including:
  - Weatherhead or service cap
  - Watertight connectors for connection at meter bases and service equipment
  - Service-cable sill plates
  - One-hole and two-hole straps
  - One-screw and two-screw connectors
- Additional information on service-entrance cable fittings can be found in the UL Product Spec (formally UL White Book) in **Category (TYZX)**

33

34



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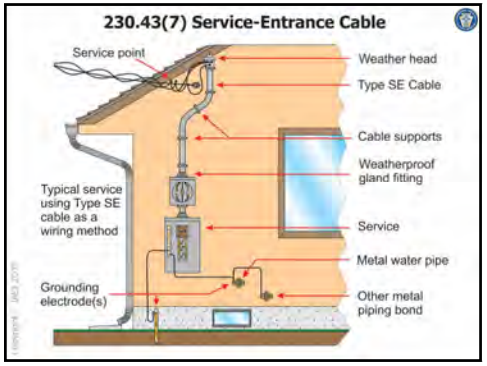
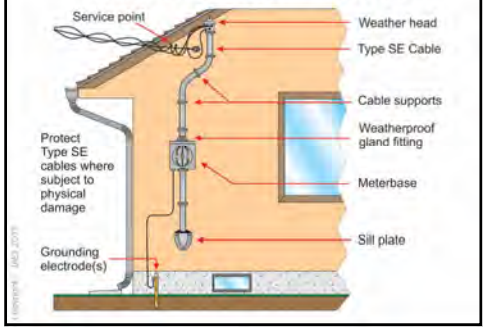


36

230.50 Protect Service-Entrance Cable



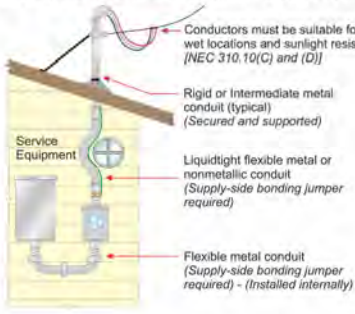
37

230.43 Raceways Permitted for Service Entrance

- Rigid metal conduit (RMC)
- Intermediate metal conduit (IMC)
- Rigid polyvinyl chloride conduit (PVC)
- Electrical metallic tubing (EMT)
- Electrical nonmetallic tubing (ENT)
- Flexible metal conduit (FMC) *[1.8 m (6 ft) lengths]*
- Liquidtight flexible metal conduit (LFMC) *[1.8 m (6 ft) lengths]*
- Liquidtight flexible nonmetallic conduit (LFNC)
- High density polyethylene conduit (HDPE)
- Nonmetallic underground conduit with conductors (NUCC)
- Reinforced thermosetting resin conduit (RTRC)

38

230.43 Service-Entrance Conductor Raceways



39

Service Disconnecting Location

- All one- and two-family dwelling services required to provide a **means of disconnect** for all service-entrance conductors installed in a building or other structure
- Service disconnecting means must be installed in a **readily accessible location**
- Permitted to be located **outside** the building or **inside** the building
  - If located inside the building, the disconnecting means must be located ***"nearest the point of entrance"*** from where the service conductors enter the building
- See *NEC* 230.70(A)(1)

40

Service Disconnecting Location *(cont.)*

- Service conductors considered **outside the building** under any of the following conditions where they are installed in:
  - Suitable raceway under not less than **50 mm (2 in.) of concrete beneath building**
  - Building, but the raceway or cable is **encased in not less than 50 mm (2 in.) of concrete** or brick
  - A vault *(not typical for dwelling units)*
  - Conduit under not less than **450 mm (18 in.) of earth** beneath the building
  - Rigid metal conduit **(RMC)** or intermediate metal conduit **(IMC)** routed **directly through an eave** *(not a wall)*
- See *NEC* 230.6

41

230.70(A)(1) Service Disconnect Location

Two different locations of service disconnecting means

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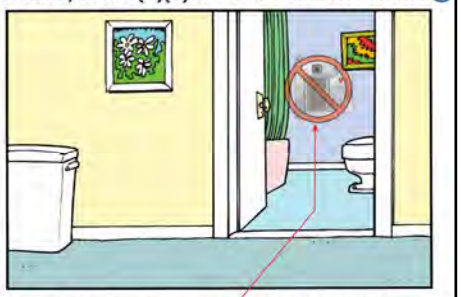
Service Disconnecting Location *(cont.)*

- Overcurrent devices *(including service OCPD)* required to be installed in a **readily accessible location** to the occupant
- Overcurrent devices restricted from being located in the following locations:
  - In the vicinity of **easily ignitible material** (such as clothes closets)
  - Over **steps of a stairway**
  - In **bathrooms** of dwelling units *(exception for supplementary OCPD)*
- Service disconnecting means are **not permitted** to be installed in bathrooms [*NEC* 230.70(A)(2)]
- See *NEC* 240.24

45

240.24, 230.70(A)(2) Service Disconnect Location



46

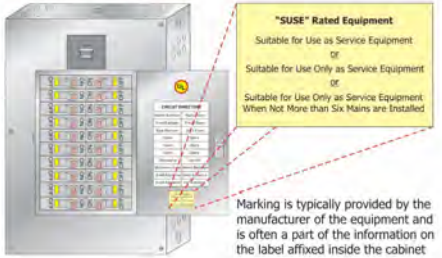
230.66 Marking of Service Disconnecting Means

- Service equipment required to be marked as being suitable for use as service equipment
- Marking provided by the manufacturer and is often a part of the information on the label affixed inside the cabinet
- Manufacturers markings will include:
  - SUITABLE FOR USE AS SERVICE EQUIPMENT
  - SUITABLE ONLY FOR USE AS SERVICE EQUIPMENT
  - SUITABLE FOR USE AS SERVICE EQUIPMENT – WHEN NOT MORE THAN SIX MAINS ARE INSTALLED
- All service equipment shall be listed or field labeled
- Also see 230.70(B)

47

230.66 Service Disconnect Suitable for the Use

Service equipment is required to be marked to identify it as being suitable for use as service equipment



Marking is typically provided by the manufacturer of the equipment and is often a part of the information on the label affixed inside the cabinet

48

230.70(B) Marking of Service Disconnecting Means

- Each service disconnect is also required to be permanently marked identifying it as a **"Service Disconnect"**
- This is in addition to the manufacturer's marking of service equipment required to be marked as being **suitable for use as service equipment** [230.66]

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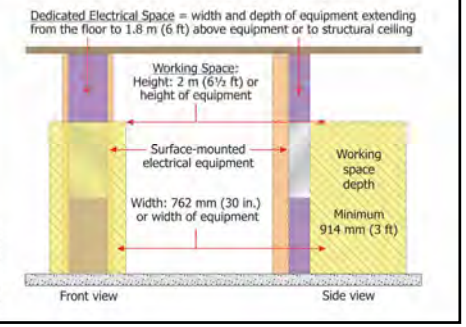
Working Space – Space About Electrical Equipment

- Ample **working space** is required in the vicinity of service equipment so any repairs, operation, or servicing of equipment can be performed safely
- Minimum **750 mm (30 in.) wide** in front or the width of the equipment whichever is greater
- Minimum headroom required – **2.0 m (6½ ft)**
- Doors to swing a minimum of **90° angle**
- **Dedicated electrical space** required above and below the electrical equipment
- Dedicated electrical space applies to both **indoor and outdoor** installations

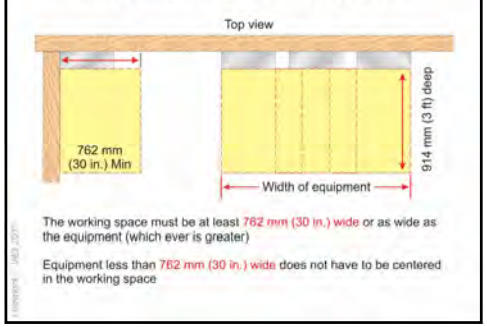
51

110.26(A) Working Space Required



52

110.26(A)(2) Width of Working Space



The working space must be at least 762 mm (30 in.) wide or as wide as the equipment (which ever is greater)

Equipment less than 762 mm (30 in.) wide does not have to be centered in the working space

53

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Limited Access Working Space

- Working space is also required around electrical equipment located in spaces with **"limited access"** such as above suspended ceilings, attics, or crawl spaces
- Strict compliance with normal working space rules in attics and crawl spaces is often not feasible and, in some cases, not possible
- Prescriptive requirements for such limited access spaces has been addressed in the latest edition of the *Code* and sorely lacking previously
- Limited access working space provisions is an attempt to provide relief for both the installer and the enforcement community
- See *NEC* 110.26(A)(4)

55

110.26(A)(4) Limited Access Working Space

Equipment installed above a lay-in ceiling to have accessible opening not smaller than 559 mm x 559 mm (22 in. × 22 in.) *[(crawl space, not smaller than* 559 mm x 762 mm *(22 in.× 30 in.)]*

Width of working space to be width of the equipment enclosure or a minimum of 762 mm (30 in.), whichever is greater

NEC Table 110.26(A)(1) depth requirements to apply in front of enclosure

Height of the working space to be the height necessary to install the equipment in the limited space

Horizontal ceiling structural member/access panel permitted in space

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Working Space – Illumination & Headroom

- **Illumination** shall be provided for all working spaces about service equipment and panelboards installed indoors
- Additional lighting outlets not required where the work space is illuminated by an **adjacent light source**
- Illumination source cannot be controlled by an **automatic means only** *(such as a motion sensor)*
- Minimum headroom required – **2.0 m (6½ ft)**
  - *Exception: In existing dwelling units, service equipment or panelboards not exceeding 200 amperes are permitted in spaces where the headroom is less than 2.0 m (6½ ft)*

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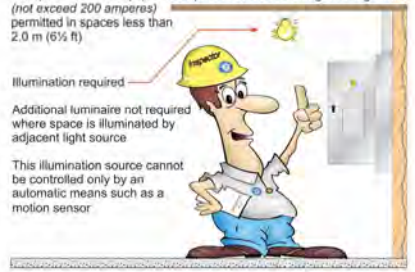
110.26(A)(3) and (D) Illumination and Headroom

Minimum headroom of 2.0 m (6½ ft) or height of equipment required

Exception: Service equipment or panelboards in existing dwellings units *(not exceed 200 amperes)* permitted in spaces less than 2.0 m (6½ ft)



Illumination required

Additional luminaire not required where space is illuminated by adjacent light source

This illumination source cannot be controlled only by an automatic means such as a motion sensor

58

Requirements for Service Disconnects

- Service disconnect required for each service permitted by 230.2 or each set of service-entrance conductors permitted by 230.40 Ex. No. 1
- Shall consist of not more than **six switches or six circuit breakers** mounted in a single enclosure or separate enclosures
- The two to six service disconnects permitted by 230.71 are required to be **grouped together**
- Each service disconnect shall be marked to indicate the load served

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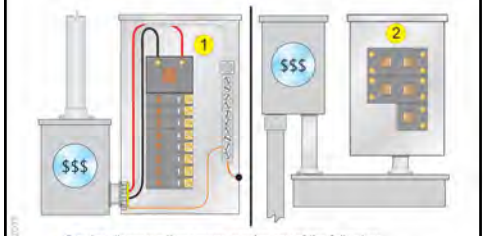
230.71(A) Maximum Number of Disconnects



Service disconnecting means can be any of the following:

1. A single "main" or...
2. Up to six grouped in a single enclosure or...
3. Up to six separate enclosures grouped in the same location

60

230.71(A) Maximum Number of Disconnects

Service disconnecting means can be any of the following:

1. A single "main" or...
2. Up to six grouped in a single enclosure or...
3. Up to six separate enclosures grouped in the same location

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Services for Outbuildings

- Section 230.40 Ex. No. 3 permits a set of service-entrance conductors to be run from a **common location** *(such as a meter socket enclosure or wireway)* to another building
- Service drop or lateral can supply either building
- Service-entrance conductors must remain **outside the structures** per 230.3
- Service disconnect(s) located to comply with 230.70(A) *(outside or inside, nearest the point of entrance)*
- Connections to service-entrance conductors or service lateral to be made in an acceptable manner in an enclosure with adequate space

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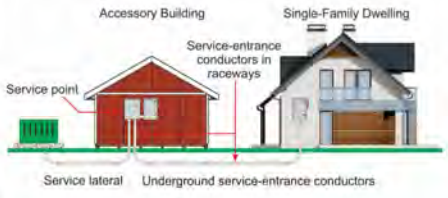
230.40 Ex. No. 3 Service-Entrance Conductor Sets

Overhead service drop to service equipment and underground service-entrance conductors to second building on same property

A single-family dwelling unit and its accessory structures shall be permitted to have one set of service-entrance conductors run to each from a single service drop, set of overhead service conductors, set of underground service conductors, or service lateral

63

230.40 Ex. No. 3 Service-Entrance Conductor Sets



A single-family dwelling unit and its accessory structures shall be permitted to have one set of service-entrance conductors run to each from a single service drop, set of overhead service conductors, set of underground service conductors, or service lateral

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Minimum Size of Service-Entrance Conductors

- Not less than the calculated load in accordance with Article 220 [230.42(A)]
- Minimum 100 amperes for one-family dwellings as required by the disconnect sizing requirements of 230.79
- Must be equal to or exceed the rating of the overcurrent device in series with service-entrance conductor [230.90(A)]

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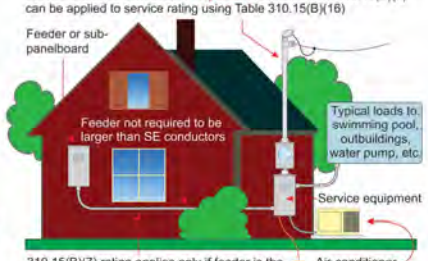
Sizing Service-Entrance Conductors for Dwelling Units

- *NEC* 310.15(B)(7) can be applied specifically to the service-entrance, service-lateral and the main power feeder conductor for dwelling units
- Applies to dwelling unit services of **120/240 volts**, 3-wire or **208Y/120 volts**, single-phase feeder conductors
- Permitted to have an ampacity not less than ***83 percent*** of the service or feeder rating based on standard ampacity ratings found at *NEC* 240.6(A)
- Permitted to be used for the feeder conductors that supply the entire load associated with the dwelling unit

66

310.15(B)(7) Permitted to be Used

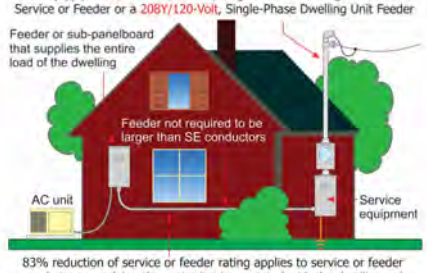
Service-entrance conductors: 83 percent reduction from 310.15(B)(7) can be applied to service rating using Table 310.15(B)(16)



67

310.15(B)(7) Permitted to be Used

310.15(B)(7) - 120/240-Volt, 3-Wire, Single-Phase Dwelling Unit Service or Feeder or a 208Y/120-Volt, Single-Phase Dwelling Unit Feeder



83% reduction of service or feeder rating applies to service or feeder conductors supplying the entire load associated with the dwelling unit

68

Informational Annex Example D7 Sizing of Service Conductors for Dwelling(s) *[See 310.15(B)(7)]*

- **With No Required Adjustment or Correction Factors**
- Service conductors and the main power feeder for certain dwellings are permitted to be sized in accordance with 310.15(B)(7)
- If a 175-ampere service rating is selected, a service conductor is then sized as follows:
- 175 amperes × 0.83 = 145.25 amperes per 310.15(B)(7)
- If no other adjustments or corrections are required for the installation, then, in accordance with Table 310.15(B)(16), a 1/0 AWG Cu or a 3/0 AWG Al meets this rating at 75°C (167°F)

Reproduction of Example D7 of NEC Informational Annex D

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Informational Annex Example D7 Sizing of Service Conductors for Dwelling(s) *[See 310.15(B)(7)]*

- **With Required Temperature Correction Factor**
- Service conductors and the main power feeder for certain dwellings are permitted to be sized in accordance with 310.15(B)(7)
- If a 175-ampere service rating is selected, a service conductor is then sized as follows:
- 175 amperes × 0.83 = 145.25 amperes per 310.15(B)(7)
- Conductors to be installed in an ambient temperature of 40°C (104°F) *[See Table 310.15(B)(2)(a)]*
- Using XHHW-2 conductors requires a correction factor of 0.91 to find the minimum conductor ampacity and size:

  145.25/.91 = 159.6 amperes
- In accordance with Table 310.15(B)(16), a 2/0 AWG Cu or a 4/0 AWG Al would be required

Reproduction of Example D7 of NEC Informational Annex D

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Informative Annex D - Example D7 Sizing of Service Conductors for Dwelling(s) *[Former Table 310.15(B)(7)]*

If no temperature correction or ampacity adjustment factors are required, the following table includes conductor sizes calculated using the requirements in 310.15(B)(7). This table is based on 75°C terminations and without any adjustment or correction factors.

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil) Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

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Overload Protection for Service-Entrance Conductors

- In most cases, each ungrounded (hot) service-entrance conductor must be protected from **overload** by an overcurrent device installed in series with the conductor that will operate during an overload
- Each ungrounded service conductor is required to have **overload protection**
- Service-entrance conductors are protected from overload at their **load end** rather than at their supply end
- See *NEC* 230.90

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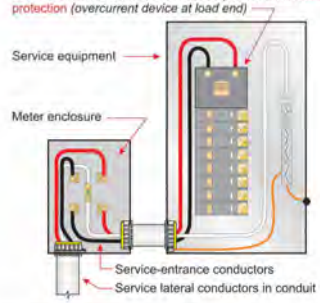
Overload Protection for Service-Entrance Conductors *(cont.)*

- An overload includes
  - Operation of equipment in excess of normal
  - Full-load rating
  - Conductor in excess of rated ampacity *(which, if it persists for a sufficient length of time, would cause damage or dangerous overheating)*
- A fault, such as a short circuit or ground fault, is not an overload

73

230.90 Overload Protection Required

Service-entrance conductors must be provided with overload protection *(overcurrent device at load end)*



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Panelboards at Dwelling Units

- Two types of panelboards are commonly used in residential occupancies
  - **Main circuit breaker** or set of fuses installed at the factory by the manufacturer *(most commonly used at dwellings)*
  - **"Main Lug Only" (MLO)** panelboard (no main breaker)
- MLO panelboard has the ungrounded service or feeder conductors connected directly to the **main lugs on the load side** rather than to a circuit breaker or set of fuses
- MLO panelboard protected from overcurrent and overload on the **supply-side of the feeder** with two main circuit breakers or two sets of fuses having a combined rating not greater than that of the panelboard

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408.36 Overcurrent Protection for Panelboards

- Generally, a panelboard is required to be protected by an overcurrent protective device having a rating not greater than that of the panelboard
- This overcurrent protective device to be located within or at any point on the supply side of the panelboard
  - **Ex. No. 1**: Individual protection not required for a panelboard used as service equipment with multiple disconnecting means *[up to six means of disconnect(230.71)]*
  - Panelboards protected in this manner shall not supply a second bus structure within the same panelboard

(cont. on next slide)

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408.36 Overcurrent Protection for Panelboards *(cont.)*

- Generally, a panelboard is required to be protected by an overcurrent protective device having a rating not greater than that of the panelboard
- This overcurrent protective device to be located within or at any point on the supply side of the panelboard
  - **Ex. No. 2:** Individual protection not required for a panelboard protected by main on its supply side *(two main circuit breakers or two sets of fuses)*
  - A panelboard employing this exception shall not contain more than 42 overcurrent devices

(cont. on next slide)

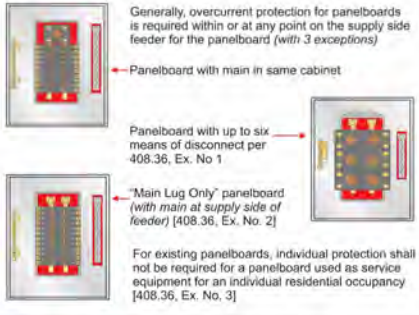
79

408.36 Overcurrent Protection for Panelboards *(cont.)*

- Generally, a panelboard is required to be protected by an overcurrent protective device having a rating not greater than that of the panelboard
- This overcurrent protective device to be located within or at any point on the supply side of the panelboard
  - **Ex. No. 3**: For existing panelboards, individual protection not required for a panelboard used as service equipment for an individual residential occupancy

80

408.36 Overcurrent Protection for Panelboards



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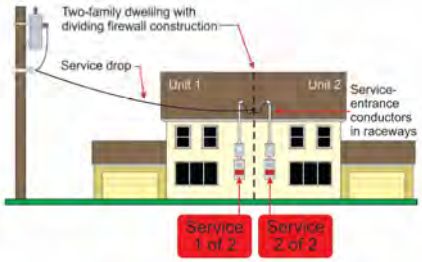
Installing Service-Entrance Equipment for Two-Family Dwellings

- Service equipment for **two-family dwellings** is usually installed in one of two methods:
  - **Locate service disconnects in or on the individual dwelling units** *(not grouped)*
    - Metering equipment at one location *(typically required by the serving utility)*
    - Service-entrance conductors run to each dwelling unit
    - Permitted by ***NEC* 230.40 Exception No. 1**
  - **Group the service disconnects at one location** *(typically near the metering equipment)*
    - Feeder run to each dwelling units to subpanel or feeder panelboard
    - Permitted by ***NEC* 230.40 Exception No. 2**
- Requirements for installing services for one-family dwellings apply for two-family dwellings as well

82

230.40 Ex. No. 1 - Number of SE Conductor Sets

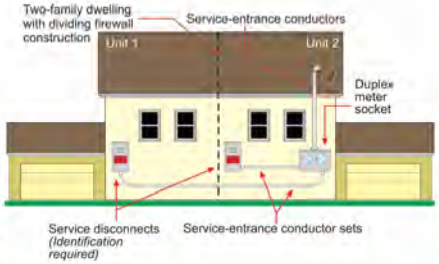
Service-entrance conductors to each occupancy from one service drop
Maximum six disconnects at one location



83

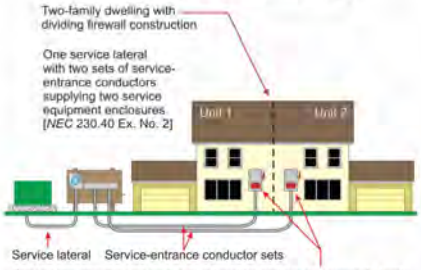
230.40 Ex. No. 1 - Number of SE Conductor Sets

Service-entrance conductors to each occupancy from one service drop
Maximum six disconnects at one location



84

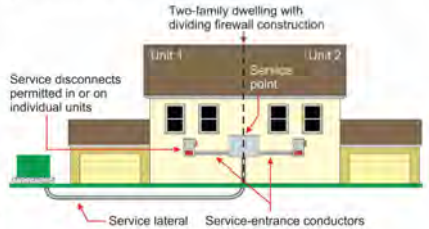
230.40 Ex. No. 2 One Service Lateral Supplying Two Service Disconnects



85

230.40 Ex. No. 1 Number of SE Conductor Sets

Buildings with more than one occupancy permitted to have one set of service-entrance conductors for each service run to each occupancy
[NEC 230.40 Ex. No. 1]



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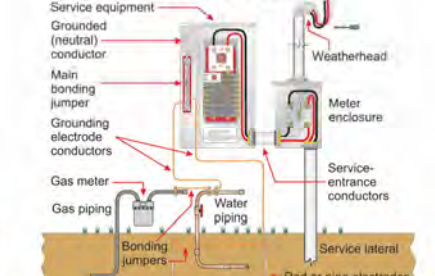
Typical Dwelling Services Components - Underground or Overhead



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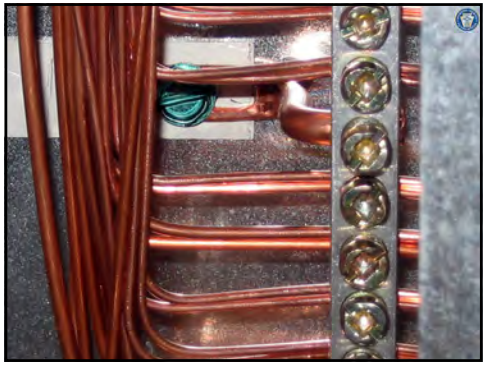

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Purpose of Grounding

- **Limit voltages** due to lightning, line surges, or unintentional contact with higher voltage lines
- Proper grounding also serves to **stabilize the voltage to ground** during normal operation [250.4(A)(1)]
- Conductive materials enclosing electrical conductors or equipment shall be connected to earth so as to **limit the voltage to ground** on these materials [250.4(A)(2)]
- Conductive materials are grounded to **limit the voltage to ground** on these materials

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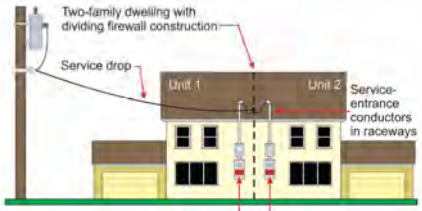
Installing Service-Entrance Equipment for Two-Family Dwellings

- Service equipment for **two-family dwellings** is usually installed in one of two methods:
  - **Locate service disconnects in or on the individual dwelling units** *(not grouped)*
    - Metering equipment at one location *(typically required by the serving utility)*
    - Service-entrance conductors run to each dwelling unit
    - Permitted by ***NEC* 230.40 Exception No. 1**
  - **Group the service disconnects at one location** *(typically near the metering equipment)*
    - Feeder run to each dwelling units to subpanel or feeder panelboard
    - Permitted by ***NEC* 230.40 Exception No. 2**
- Requirements for installing services for one-family dwellings apply for two-family dwellings as well

82

230.40 Ex. No. 1 - Number of SE Conductor Sets

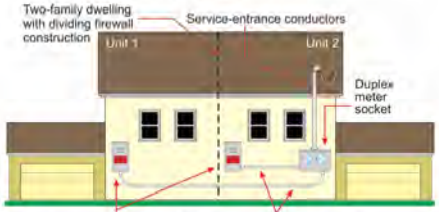
Service-entrance conductors to each occupancy from one service drop
Maximum six disconnects at one location



83

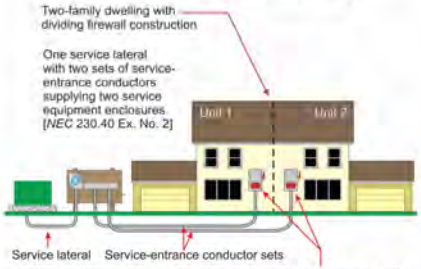
230.40 Ex. No. 1 - Number of SE Conductor Sets

Service-entrance conductors to each occupancy from one service drop
Maximum six disconnects at one location



84

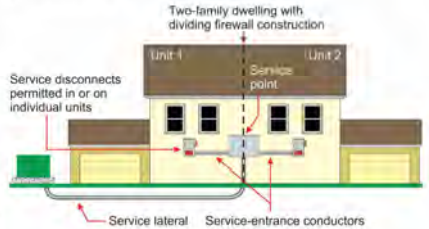
230.40 Ex. No. 2 One Service Lateral Supplying Two Service Disconnects



85

230.40 Ex. No. 1 Number of SE Conductor Sets

Buildings with more than one occupancy permitted to have one set of service-entrance conductors for each service run to each occupancy [NEC 230.40 Ex. No. 1]



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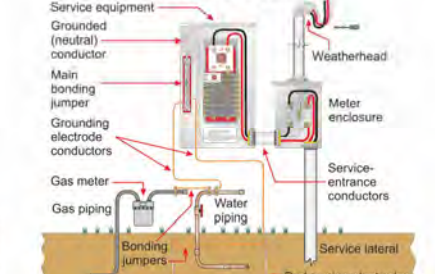
Typical Dwelling Services Components - Underground or Overhead



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Grounding and Bonding

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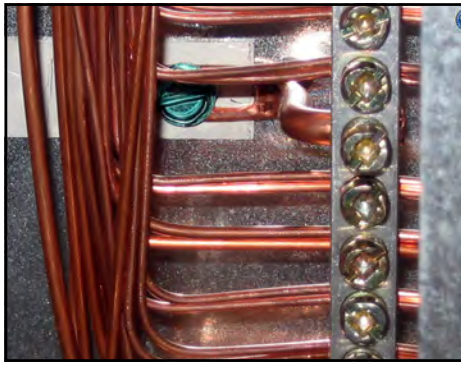


89

Purpose of Grounding

- **Limit voltages** due to lightning, line surges, or unintentional contact with higher voltage lines
- Proper grounding also serves to **stabilize the voltage to ground** during normal operation [250.4(A)(1)]
- Conductive materials enclosing electrical conductors or equipment shall be connected to earth so as to **limit the voltage to ground** on these materials [250.4(A)(2)]
- Conductive materials are grounded to **limit the voltage to ground** on these materials

90

Purpose of Bonding

- **Electrically conductive materials** such as metal water piping, metal gas piping, and structural steel members are to be **bonded** to the supply system grounded conductor in a manner which **establishes an effective path for fault current** [250.4(A)(3) and (4)]
- **Effective fault current path** must be continuous, capable of carrying the maximum fault current likely to be imposed on it, and shall have low impedance to facilitate overcurrent device operation [250.4(A)(5)]

91

Article 100: Definitions

- **Bonded (Bonding):** "Connected to establish electrical continuity and conductivity."
- **Bonding Conductor or Jumper:** "A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected."
- **Bonding Jumper, Equipment:** "The connection between two or more portions of the equipment grounding conductor."
- **Bonding Jumper, Main:** "The connection between the grounded conductor and the equipment grounding conductor at the service."

92

Article 100: Definitions

- **Bonding Jumper, System::** "The connection between the grounded circuit conductor and the supply-side bonding jumper, or the equipment grounding conductor, or both, at a separately derived system."
- **Bonding Jumper, Supply-Side:** "A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected." (250.2)
- **Effective Ground-Fault Current Path:** "An intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground fault detectors."

93

Article 100: Definitions

- **Ground:** "The earth."
- **Ground Fault:** "An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non–current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth."
- **Grounded (Grounding):** "Connected (connecting) to ground or to a conductive body that extends the ground connection."
- **Grounded Conductor:** "A system or circuit conductor that is intentionally grounded."

94

Article 100: Definitions

- **Ground-Fault Current Path:** "An electrically conductive path from the point of a ground fault on a wiring system through normally non–current-carrying conductors, equipment, or the earth to the electrical supply source."
  - ***Informational Note:*** *Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; and the earth itself.*

95

Article 100: Definitions

- **Grounding Conductor, Equipment (EGC):** "The conductive path(s) that provides a ground-fault current path and connects normally non–current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both."
- **Grounding Electrode:** "A conducting object through which a direct connection to earth is established."
- **Grounding Electrode Conductor:** "A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system."

96

Article 100: Definitions

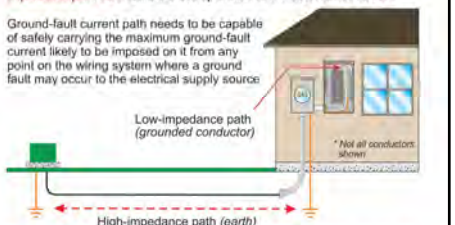
- **Intersystem Bonding Termination:** "A device that provides a means for connecting intersystem bonding conductors for communications systems to the grounding electrode system."

97

250.4(A)(5) Effective Ground-Fault Current Path

Electrical equipment, wiring and other electrically conductive material likely to become energized must be installed in a manner that creates a low-impedance path that facilitates the operation of the overcurrent device

Ground-fault current path needs to be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source



The earth shall not be considered as an effective ground-fault current path

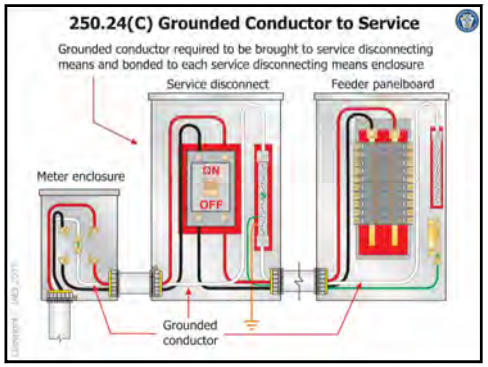
98

99

250.24 (C) Grounded *(Neutral)* Conductor Brought to Service Equipment

- Where ac system *(less than 1000 volts)* is grounded at any point, generally the **grounded conductor** *(usually a neutral conductor in dwellings)* required to be run to and bonded to each service-disconnecting means enclosure
- Grounded conductor must be **routed with the service-entrance phase conductors**
- Grounded *(neutral)* service conductor serves **dual role**:
  - Allows line-to-neutral loads to be served
  - Typically the **lowest impeded path** for ground-fault current in faulted conditions *(provides low-impedance path from the service to the utility transformer)*

100



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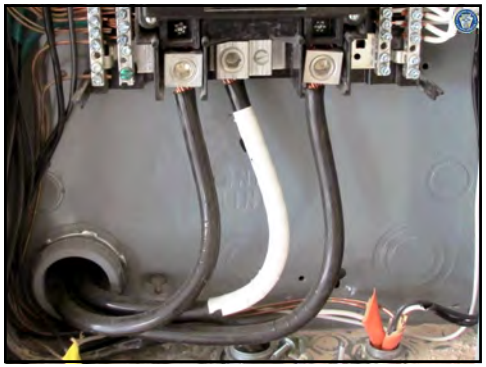
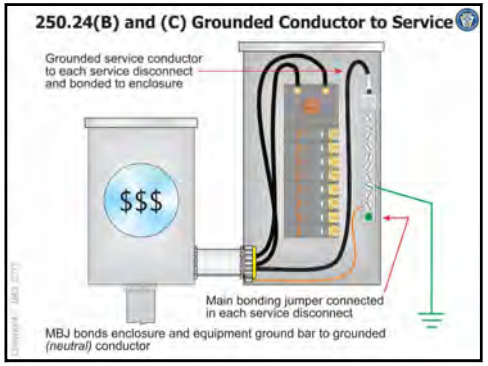


102

250.24 (B) and (C) MBJ Bonding Grounded *(Neutral)* Conductor at Service

- Where ac system *(less than 1000 volts)* is grounded at any point, generally the **grounded conductor** *(usually a neutral conductor in dwellings)* required to be run to and bonded to each service-disconnecting means enclosure
- For grounded systems, an unspliced **main bonding jumper** is generally required to be installed to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor **within each service disconnect**

103



104

250.28 Main Bonding Jumper

- Main bonding jumpers must be of **copper or other corrosion-resistant material**
- Main bonding jumper is required to be in the form of:
  - Wire
  - Bus
  - Screw *(green color finish)*
  - Similar suitable conductor *(strap)*
- For dwelling units, a properly sized main bonding jumper will usually be included as part of a **listed panelboard**
- Sizing of a **wire-type main bonding jumper** would be based on *NEC* **Table 250.102(C)(1)**

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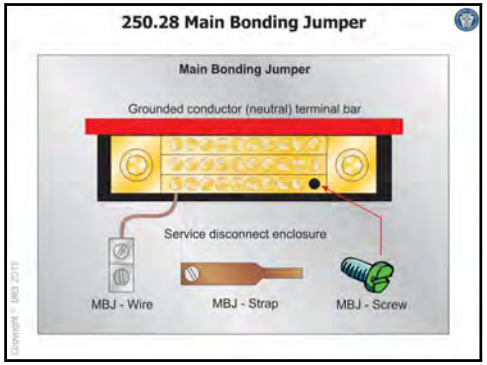

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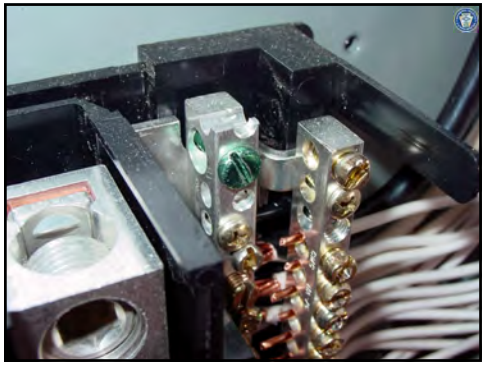


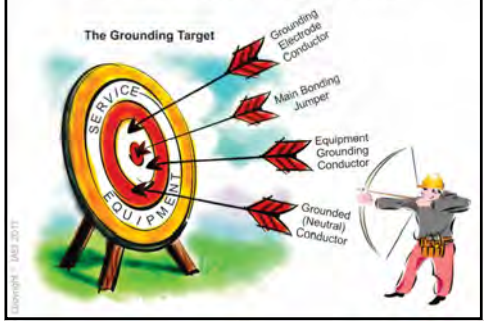
108

The Grounding Target

- For grounded electrical systems, **four conductors or components** must come together in the service equipment for effective grounding and bonding
- These four conductors connected within the service equipment are sometimes referred to as the ***"grounding target"***
- The four conductors are:
  - Grounded service conductor (neutral conductor)
  - Main bonding jumper
  - Grounding electrode conductor(s)
  - Equipment grounding conductor(s)

109

The "Grounding Target" at the Service



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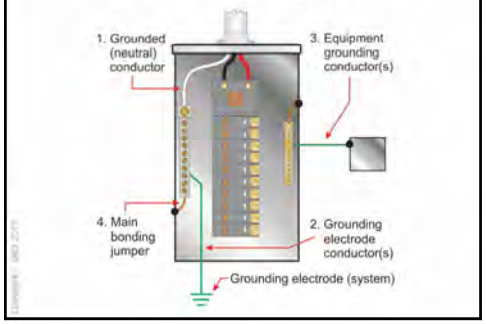
The "Grounding Target" at the Service



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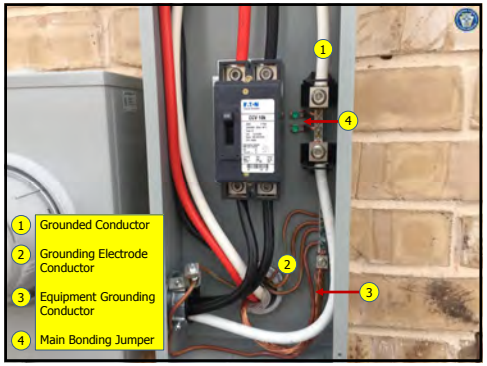

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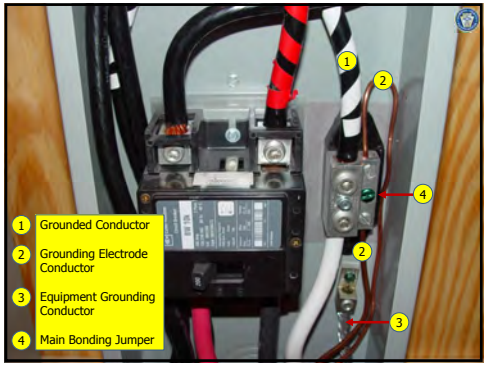


113

250.92(A) Bonding Requirements at Service Equipment

- All non–current-carrying metal parts of service equipment must be **effectively bonded together** including:
  - Service raceways
  - Service equipment enclosures containing service conductors (including meter fittings, boxes, or the like)
  - Metallic raceway or armor enclosing a grounding electrode conductor
- Bonding of these enclosures is critical as there is **no overcurrent protection** on the line (supply) side of service equipment
- Effective bonding provides a **low-impedance path** for fault current back to the source *(usually utility transformer)*

114

250.92(B) Methods of Bonding Service Equipment

- Bonding of metallic enclosures and raceways at service equipment must be effective
- Electrical continuity at service equipment on the **line side** is to be ensured by any of the following methods:
  - Bonding of the service equipment to the **grounded (neutral) service conductor**
  - **Threaded couplings** and **threaded hubs** on enclosures with joints that are made up wrenchtight
  - **Threadless couplings and connectors** made up tight for metal raceways and metal-clad cables
  - Other listed devices, such as **bonding-type locknuts**, **bonding bushings**, or bushings with bonding jumpers

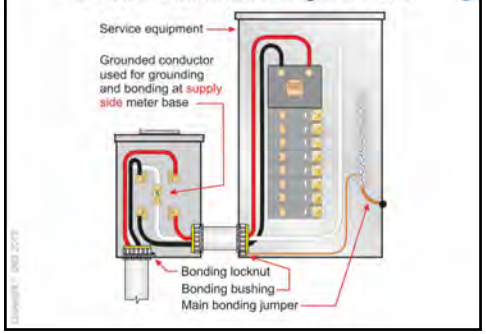
115

250.142 Use of Grounded (Neutral) Circuit Conductor for Grounding Equipment

- Grounded *(neutral)* conductor is **permitted** to be used to ground non–current-carrying metal parts of equipment, raceways and other enclosures on the **supply (line) side** of a service disconnecting means *[NEC 250.142(A)]*
- Neutral conductor terminal bar is typically **bonded to the enclosure** at the factory in listed meter socket
- Neutral conductor serves as bonding conductor between the meter socket and the service enclosure
- Generally, **not permitted** to use the system grounded conductor *(often a neutral conductor)* for bonding or grounding equipment downstream from the service equipment ***(load side)*** *[NEC 250.142(B)]*

116

250.92 and 250.142 Bonding at Services



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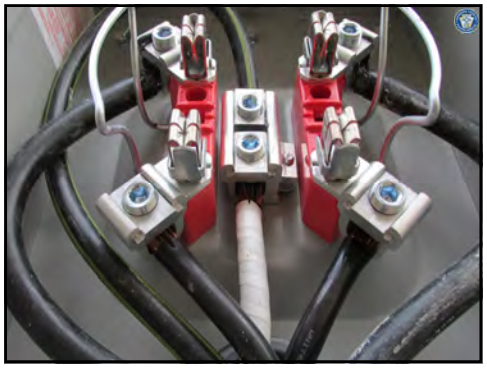

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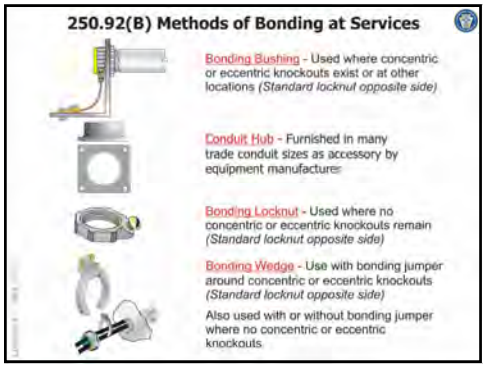

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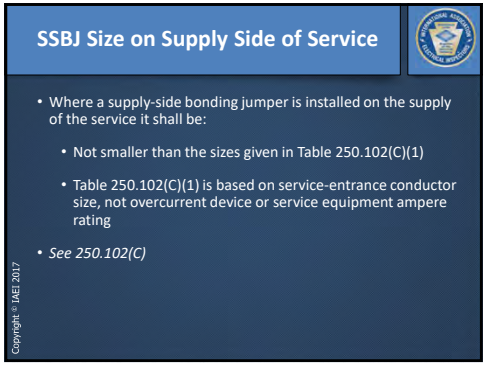

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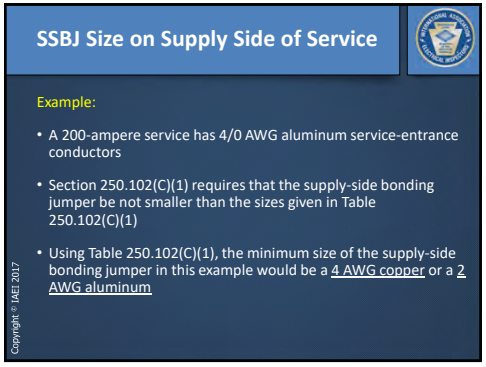

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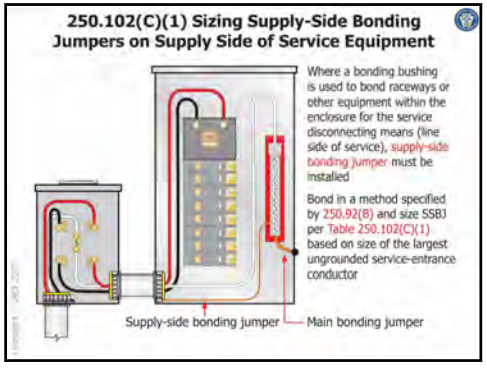

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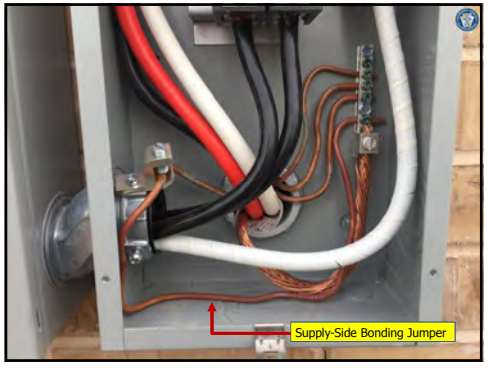

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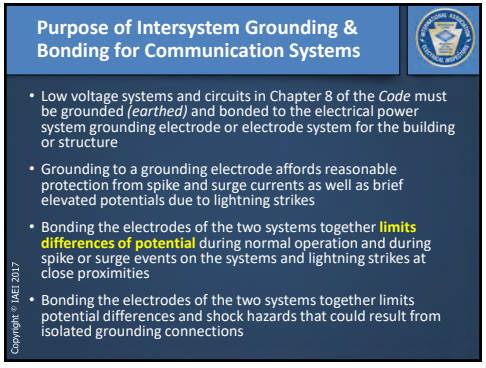

126

Article 100: Definitions

- **Intersystem Bonding Termination:** "A device that provides a means for connecting intersystem bonding conductors for **communications systems** to the grounding electrode system."

127

250.94 Intersystem Bonding for Communication Systems

- An ***intersystem bonding termination (IBT)*** for connecting intersystem bonding conductors required for communication systems shall be provided **external to enclosures** at the service or metering equipment and at the disconnecting means for any additional buildings or structures
- A **listed IBT device** shall comply with the following:
  - Be accessible for connection and inspection
  - Have the capacity for connection of **not less than three** intersystem bonding conductors
  - Not interfere with opening a service or metering equipment enclosure

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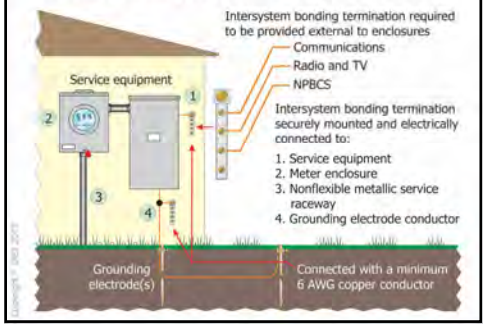
250.94 Intersystem Bonding for Communication Systems *(cont.)*

- A **listed IBT device** shall comply with the following: *(cont.)*
  - Listed as grounding and bonding equipment
  - Securely mounted and electrically connected to:
    - Service equipment
    - Meter enclosure
    - Building disconnecting means
    - Exposed nonflexible metallic service raceway or…
  - Mounted at one of these enclosures and be connected to the enclosure or to the grounding electrode conductor with a minimum **6 AWG copper conductor**

129

250.94 Bonding for Communication Systems



130

Intersystem Bonding termination is required to be:

- External to the enclosure
- Accessible for connection and inspection

- Capable of connection of not less than three intersystem bonding conductors
- Shall not interfere with the opening of any service or metering equipment enclosure
- Listed as grounding and bonding equipment

Courtesy of Thomas and Betts

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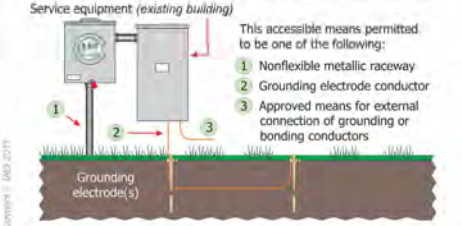
250.94 Exception: Intersystem Bonding and Grounding at Existing Buildings

- At **existing buildings**, an accessible means external to the service equipment enclosure and at the disconnecting means for any additional buildings or structures shall be permitted for intersystem bonding and grounding conductors [250.94, Exception]
  - Exposed nonflexible metallic service raceway(s)
  - Exposed grounding electrode conductor
  - A 6 AWG copper bonding or grounding electrode conductor not shorter than 150 mm (6 in.) and bonded to the service equipment enclosure or raceway with a listed and identified fitting

133

250.94(A) Ex. - Bonding for Communication Systems at Existing Buildings or Structures

In lieu of an intersystem bonding termination, at existing installations, an accessible means external to enclosures is permitted to be provided for connection of communication bonding conductors at service equipment where any intersystem bonding and grounding electrode conductors exist



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Grounding Electrode System

- Grounding electrodes provide essential function of **connecting** the electrical system and electrical equipment **to the earth**
- Primary purpose of grounding electrode(s) is to maintain the electrical equipment at the **same voltage potential** as the earth voltage potential where the grounding electrode(s) is located
- Another essential function of the grounding electrode(s) is to **dissipate overvoltages** into the earth
- *Code* requires equipment grounding conductors, service-equipment enclosures, grounded service conductor to be connected to the grounding electrode(s) [*NEC* 250.24(D)]
- Conductor used to make this connection is the **grounding electrode conductor**

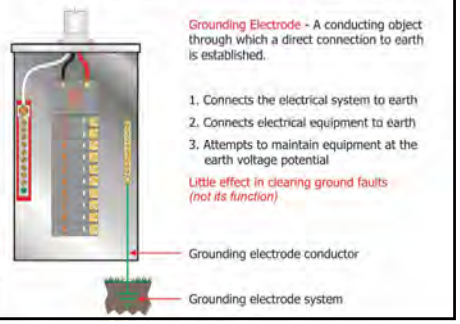
136

Article 100: Definitions

- ***Grounding electrode***: "A conducting object through which a direct connection to earth is established."
- This definition needs to be used cooperatively with the list of electrodes identified in *NEC* 250.52(A)
- List of grounding electrodes can be a device or other conducting object such as a building footing or metal well casing that establishes and maintains a direct connection to the earth
- Resistance in the connection between an electrode and the earth will vary based on:
  - Soil conditions
  - Electrode depth
  - Type of electrode
  - Seasonal conditions or geographical location(s)

137

Major Functions of Grounding Electrode(s)



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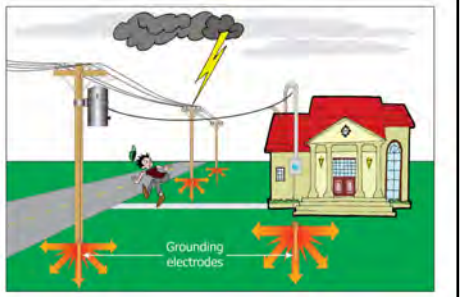
Dissipation of Overvoltages



139

250.50 Grounding Electrode System

- These grounding electrodes are required to be used **where present**
- If any of these electrodes are inherent to the building or structure or installed, they shall be used in the grounding electrode system:
  - 250.52(A)(1) Metal underground water pipe
  - 250.52(A)(2) Metal frame of a building or structure
  - 250.52(A)(3) Concrete-encased electrode
  - 250.52(A)(4) Ground ring
  - 250.52(A)(5) Rod and pipe electrode
  - 250.52(A)(6) Other listed electrodes
  - 250.52(A)(7) Plate electrodes
  - 250.52(A)(8) Other local metal underground systems or structures

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250.50 Grounding Electrode System

- Where none of the grounding electrodes described in 205.52(A)(1) through (7) are present, one or more of the grounding electrodes specified below shall be installed and used:
  - 250.52(A)(4) Ground ring
  - 250.52(A)(5) Rod and pipe electrode
  - 250.52(A)(6) Other listed electrodes
  - 250.52(A)(7) Plate electrodes
  - 250.52(A)(8) Other local metal underground systems or structures

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250.52(A) Grounding Electrodes

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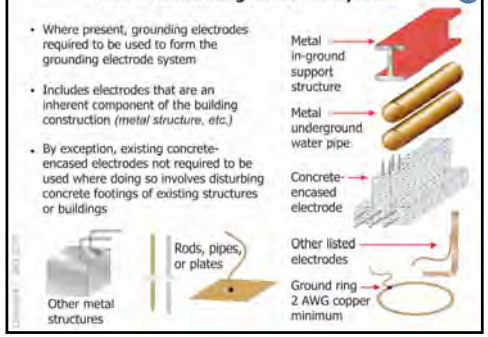
250.50 Grounding Electrode System

- Where present, grounding electrodes required to be used to form the grounding electrode system
- Includes electrodes that are an inherent component of the building construction *(metal structure, etc.)*
- By exception, existing concrete-encased electrodes not required to be used where doing so involves disturbing concrete footings of existing structures or buildings



143

250.52(A)(1) Metal Underground Water Piping Systems

- **Metal underground water piping systems** required to be used for the grounding electrical systems *(where present)*
- Must be in direct contact with the earth for 3.0 m (10 ft) or more and electrically continuous
- Includes any metal well casing bonded to the pipe
- Can be made electrically continuous by bonding around insulating joints or insulating pipe
- Must not be coated or otherwise insulated from direct contact with the earth

144

250.53(D)(2) Supplemental Electrode Required

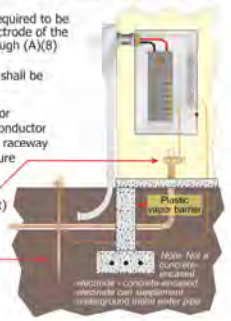
Metal underground water pipe is required to be supplemented by an additional electrode of the type specified in 250.52(A)(2) through (A)(8)

Supplemental grounding electrode shall be bonded to one of the following:

(1) Grounding electrode conductor
(2) Grounded service-entrance conductor
(3) Nonflexible grounded service raceway
(4) Any grounded service enclosure
(5) As provided by 250.32(B)

Connection within first 1.52 m (5 ft)

If the supplemental grounding electrode is a single rod, pipe, or plate, must be supplemented as well or must meet 25-ohm rule [250.53(A)(2) and Exception]



145

250.52(A)(2) Metal In-Ground Support Structure(s)

- **Metal in-ground support structure** required to be used for the grounding electrical systems *(where present and qualifies)*
- Must be in direct contact with the earth vertically for **3.0 m (10 ft) or more** *(with or without concrete encasement)*
- If multiple metal in-ground support structures are present, **permitted to bond only one** into the grounding electrode system
- Could include *(but are not limited to)* pilings, casing, and other structural metal
- Metal in-ground support structures uncommon for dwelling unit construction

146

250.52(A)(3) Concrete-Encased Electrode

- **Concrete-encased electrodes** required to be used when consisting of:
  - At least **6.0 m (20 ft)** of bare copper conductor not smaller than **4 AWG** or one or more bare or electrically conductive coated steel reinforcing bars or rods of not less than **13 mm (½ in.) in diameter**
  - Installed in **one continuous 6.0 m (20 ft) length**, or multiple pieces connected together by the usual steel tie wires, exothermic welding, welding, etc. to create a 6.0 m (20 ft) or greater length
  - Metallic components encased by at least **50 mm (2 in.) of concrete**
  - Located **horizontally** within portions of a concrete foundation or footing or **vertical** structural components in direct contact with the earth

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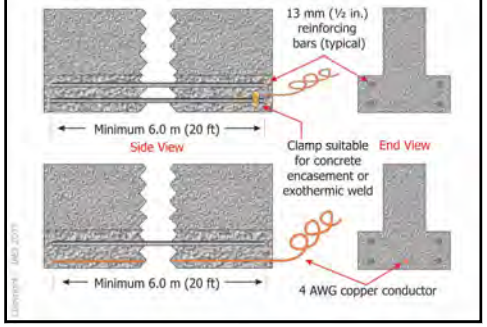
250.52(A)(3) Concrete-Encased Electrodes

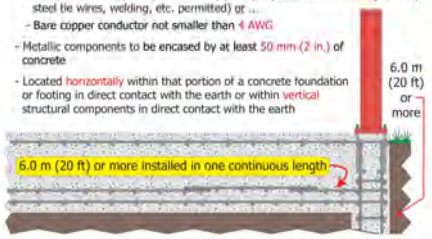


148

250.52(A)(3) Concrete-Encased Electrodes

Concrete-encased electrode to consist of:

- At least one continuous 6.0 m (20 ft) or more length of either:
  - One or more electrically conductive coated steel reinforcing bars or rods not less than ±3 mm (⅛ in.) in diameter, (multiple pieces connected together by steel tie wires, welding, etc. permitted) or ...
  - Bare copper conductor not smaller than 4 AWG
- Metallic components to be encased by at least 50 mm (2 in.) of concrete
- Located horizontally within that portion of a concrete foundation or footing in direct contact with the earth or within vertical structural components in direct contact with the earth



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

- Common practice to extend a **rebar-type extension** from a concrete-encased electrode out of the footing or foundation before the slab or foundation is poured
- Typically accomplished by using a piece of rebar connected to the concrete-encased electrode and **"stubbed-up"** out of the poured concrete to provide an **accessible connection point** above the slab
- Electrician can make the grounding electrode conductor connection after the foundation has been poured and cured
- The extension or "stub-up" is not part of the concrete-encased electrode

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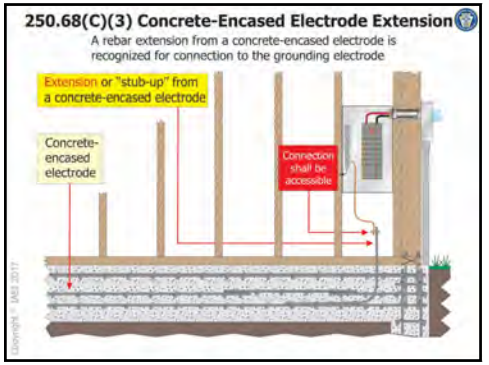
250.68(C)(3) Concrete-Encased Electrode Extension

A rebar extension from a concrete-encased electrode is recognized for connection to the grounding electrode



153

154

250.52(A)(5) Rod or Pipe Electrodes

- Requirements or conditions a **rod and pipe electrode** must meet to qualify as a grounding electrode are as follows:
  - Not be less than 2.44 m (8 ft) in length
  - **Pipe or conduit grounding electrodes** must consist of the following materials:
    - Not smaller than metric designator 21 (trade size ¾)
    - Where of steel, outer surface must be galvanized or otherwise metal-coated for corrosion protection

155

250.52(A)(5) Rod or Pipe Electrodes *(cont.)*

- Requirements or conditions a **rod and pipe electrode** must meet to qualify as a grounding electrode are as follows:
  - Not be less than 2.44 m (8 ft) in length
  - **Rod-type grounding electrodes** must consist of the following materials:
    - Stainless or copper or zinc coated steel
    - At least 15.87 mm (⅝ in.) in diameter, unless listed

156

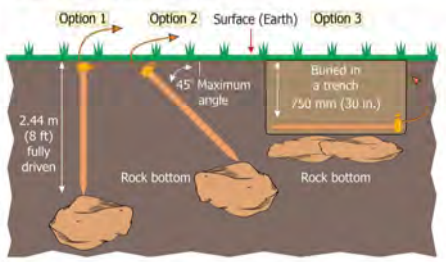
250.53(G) Installation of Rod and Pipe Electrodes

- **Rod and pipe electrodes** required to be installed with least **2.44 m (8 ft)** is in contact with the soil
- Required to be **driven vertically** unless rock bottom is encountered
- If rock bottom is encountered *(preventing rod or pipe from being driven 2.44 m (8 ft) vertically)*, rod or pipe permitted to be installed at an **oblique angle** of not more than **45 degrees** from vertical
- Where driven at an angle cannot be achieved, only then can the rod or pipe be **buried in a trench** that is at least **750 mm (30 in.)** deep

157

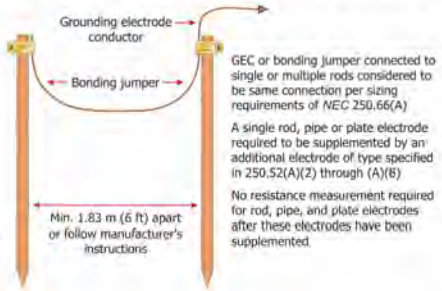
250.53(G) Installation of Rod or Pipe Electrodes

Rod or pipe electrodes must be installed such that at least 2.44 m (8 ft) of length is in contact with the soil (earth)



158

250.53(A)(2) Supplemental Electrode Required



GEC or bonding jumper connected to single or multiple rods considered to be same connection per sizing requirements of *NEC* 250.66(A)

A single rod, pipe or plate electrode required to be supplemented by an additional electrode of type specified in 250.52(A)(2) through (A)(8)

No resistance measurement required for rod, pipe, and plate electrodes after these electrodes have been supplemented.

159

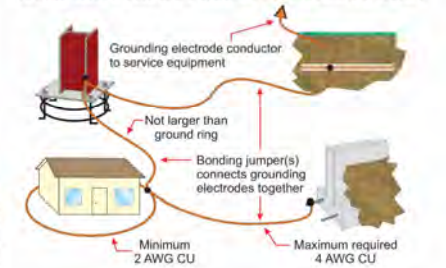
250.58 Common Grounding Electrode

- A grounding electrode system may consist of **one or more electrodes**
- The same **"common grounding electrode"** to be used to ground *(connect to earth)* conductor enclosures and equipment in or on a building or structure
- Prohibited from installing one grounding electrode for the electrical service or system and another one for grounding electrical equipment *(such as a hydromassage tub motor)*
- Two or more services supply a single building required to be connected to the **same grounding electrode system**
- Two or more grounding electrodes that are effectively bonded together are considered as a **single or common grounding electrode**

160

250.58 Common Grounding Electrode

The same "common grounding electrode" to be used to ground *(connect to earth)* conductor enclosures and equipment in or on a building or structure

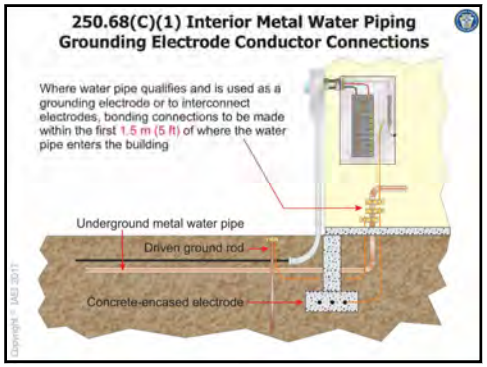


161

250.68(C)(1) Sizing Grounding Electrode System Bonding Jumpers

- Bonding jumper installed to connect multiple grounding electrodes together for the system must be sized in accordance with *NEC* Table 250.66
- Where **interior metal water pipe** is used to bond other electrodes together *(such as concrete-encased electrodes, building in-ground support structures, or a ground ring)*, bonding connections must be made **within the first 1.5 m (5 ft)** from where water pipe enters the building
- At a dwelling unit, metal water pipe is **not permitted** to be used for bonding the grounding electrodes together beyond this first **1.5 m (5 ft)**

162



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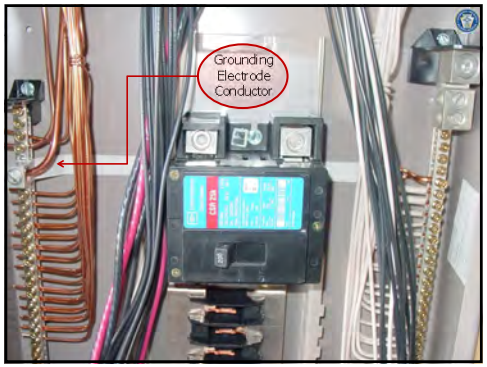

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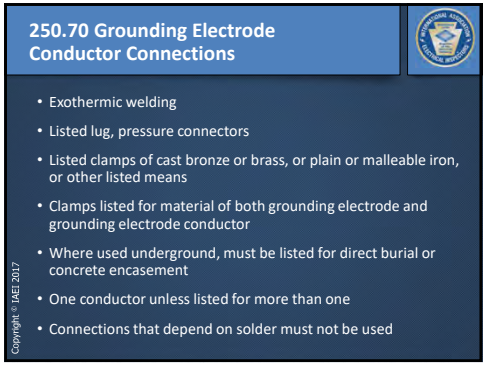

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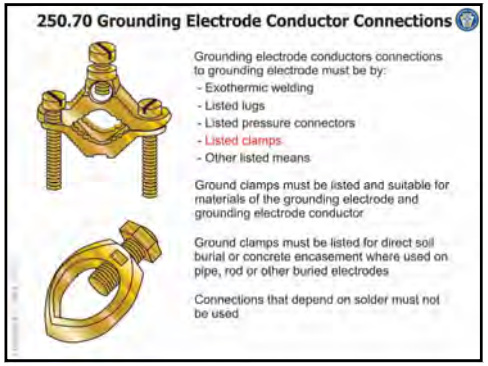

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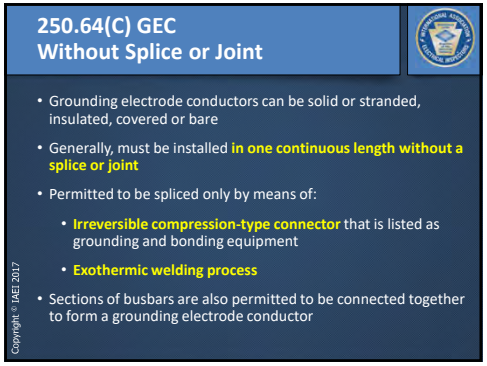

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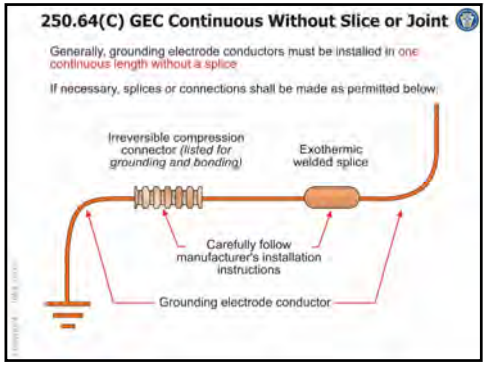

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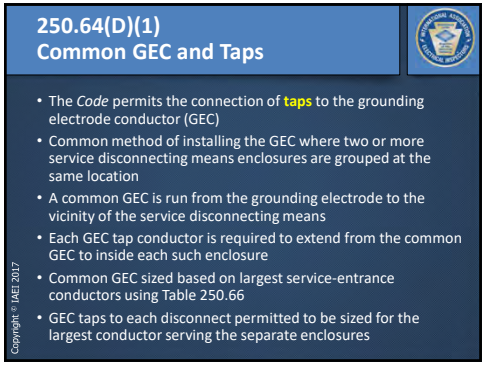
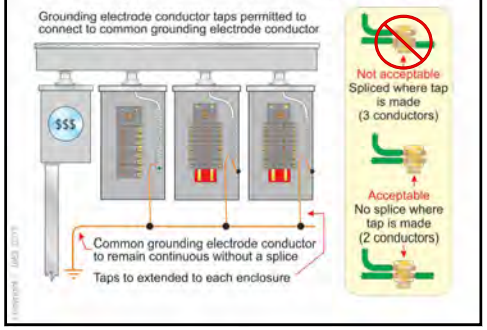


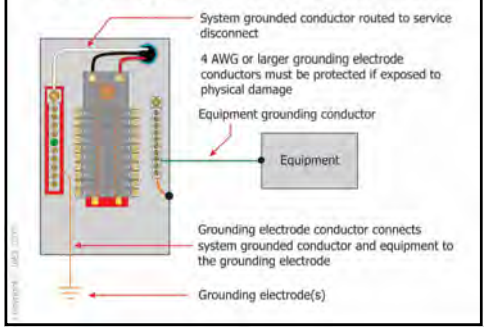
171

250.64(D)(1) Grounding Electrode Conductor Taps



172

Grounding Electrode Conductor Installation



173

250.66 Sizing of Grounding Electrode Conductors

- Sizing of grounding electrode conductor(s) (GEC) cannot be less than that given in *NEC* **Table 250.66**
- Size of the GEC is based on the **size of the largest service-entrance conductor** *(not on the rating of the circuit breaker or fuse in the service equipment)*
- To use **Table 250.66**:
  - Determine the size of the largest service-entrance conductor
  - Is it copper or aluminum?
  - Follow column for the size and type of conductor down until the size of the largest service-entrance conductor is found
  - Move to the right to find the copper or aluminum GEC required

174

250.66 Sizing of Grounding Electrode Conductors *(cont.)*

- Note that neither the ampere rating of the service equipment nor the ampere rating of a main breaker or fuse is used to determine the size of the GEC
- Ampere rating of the service equipment or the main circuit breaker or fuse could be used to determine the size of the largest service-entrance conductors
- **Example**: If the size of the service-entrance conductors is **400 kcmil copper**, the GEC must be either **1/0 AWG copper** or **3/0 AWG aluminum**
- *NEC* **250.66(A), (B), and (C)** give specific sizes of GECs for connection to rod, pipe, or plate electrodes; concrete-encased electrodes; or a grounding electrode ring that **do not extend** on to other types of electrodes that require a larger size conductor

175

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors[2] (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum[3]
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 2/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Notes:
1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.
2. Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.
[3] This table also applies to the derived conductors of separately derived ac systems
[2] See installation restrictions in 250.64(A)

176

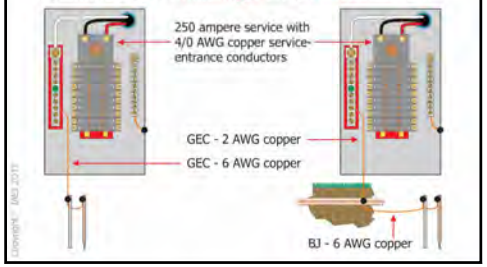
250.66 Sizing of Grounding Electrode Conductors *(cont.)*

- Grounding electrode conductors are generally required to be not smaller than the values in **Table 250.66**
- Grounding electrode conductor or bonding jumper may be sized as follows where **not extended on to other types of electrodes that require a larger size conductor**:
  - Not required to be larger than 6 AWG copper or 4 AWG aluminum to **rod, pipe, or plate** type grounding electrodes *[250.66(A)]*
  - Not required to be larger than 4 AWG copper to **concrete-encased electrode** *[250.66(B)]*
  - Not larger than the **ground ring** conductor *[250.66(C)]*

177

250.66(A) Sizing Grounding Electrode Conductors

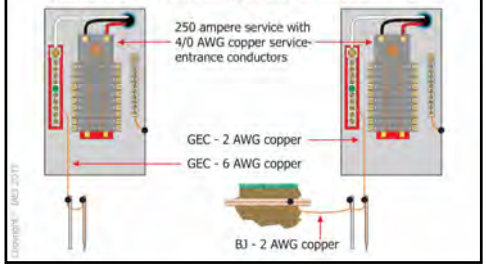
GEC or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof does not extend on to other types of electrodes that require a larger size conductor, the GEC shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum wire



178

250.66(A) Sizing Grounding Electrode Conductors

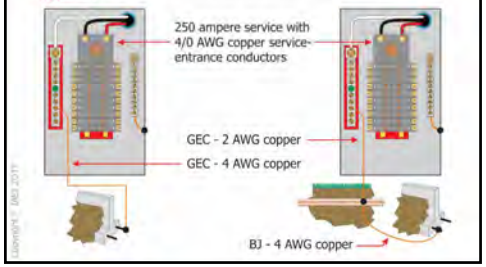
GEC or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof does not extend on to other types of electrodes that require a larger size conductor, the GEC shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum wire



179

250.66(B) Sizing Grounding Electrode Conductors

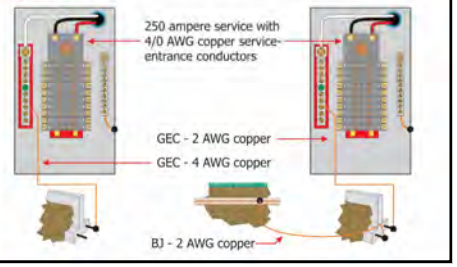
GEC or bonding jumper connected to a single or multiple concrete-encased electrode(s) that does not extend on to other types of electrodes that require a larger size conductor, the GEC shall not be required to be larger than 4 AWG copper wire



180

250.66(B) Sizing Grounding Electrode Conductors

GEC or bonding jumper connected to a single or multiple concrete-encased electrode(s) that does not extend on to other types of electrodes that require a larger size conductor, the GEC shall not be required to be larger than 4 AWG copper wire



181

250.64(B) Grounding Electrode Conductor Installation

- Must be **securely fastened** to mounting surface if exposed
- Permitted to be installed on or through framing members
- Sizes 4 AWG or larger copper or aluminum conductor must be protected if exposed to physical damage
- A 6 AWG that is free from physical damage is permitted to be run on surface, otherwise protected by installation in raceway or armor
- GEC smaller than 6 AWG must be protected by installation in raceway or armor

182

250.64(A) Grounding Electrode Conductor Installation

- Bare aluminum GEC not to be in contact with masonry or earth or subject to corrosive conditions
- Aluminum GEC not to be terminated within **450 mm (18 in.)** of earth

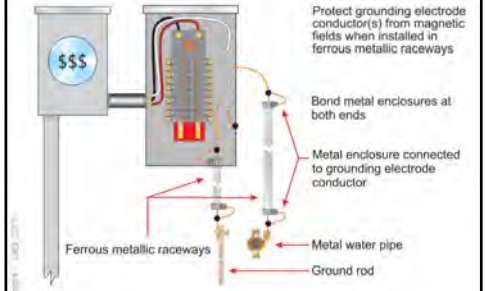
183

250.64(E) Bonding Metal Enclosures for Grounding Electrode Conductors

- Common practice to enclose a grounding electrode conductor in a **raceway** or enclosure to protect it from **physical damage**
- If the raceway or enclosure is **ferrous metal**, the *Code* requires the metallic enclosure to be protected from **magnetic fields**
- Required to bond ferrous metallic raceways and enclosures for GECs to the GEC itself
- Bonding puts the ferrous metallic enclosure and the GEC in **parallel** with each other
- Ferrous metal enclosures for GECs required to be **electrically continuous** from the point of attachment to cabinets or equipment to the grounding electrode
- Bonding jumper(s) required to be at least the same size as the GEC itself

184

250.64(E) Ferrous Metal Enclosures for GEC



185

250.104(A) Bonding of Metal Water Piping Systems

- Metal water piping systems are required to be bonded to one of the following:
  - The service equipment enclosure
  - The grounded (neutral) conductor at the service
  - The grounding electrode conductor where of sufficient size, or…
  - To the one or more grounding electrodes used *(GEC or bonding jumper of sufficient size)*
- The metallic water piping system required to be bonded would include ether piping systems installed in or attached to a building or structure

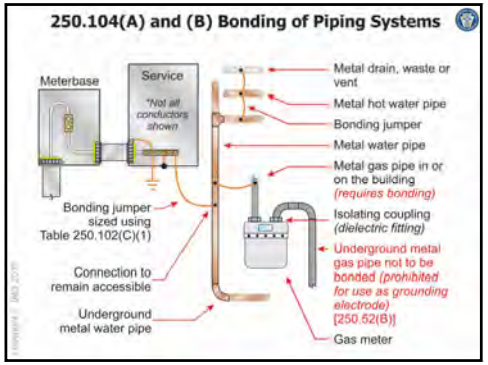
186

250.104(A) Bonding of Metal Water Piping Systems *(cont.)*

- The metal water piping system bonding jumper must be sized in accordance with *NEC* Table 250.66 *(just as though this bonding conductor were being connected to the metal water pipe as a grounding electrode conductor)*
- Bonding applies to both supply and metal drain lines
- Points of attachment of the bonding jumper to the metal piping are required to be accessible

187

250.104(A) and (B) Bonding of Piping Systems



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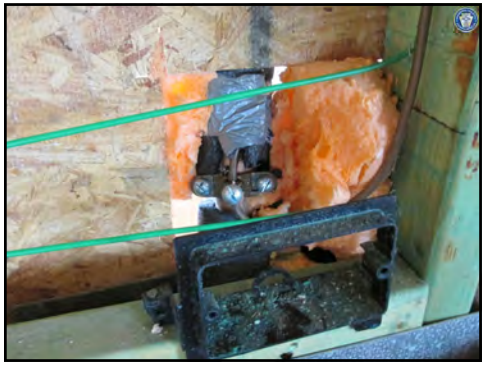

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190

250.104(B) Bonding of Other Piping Systems

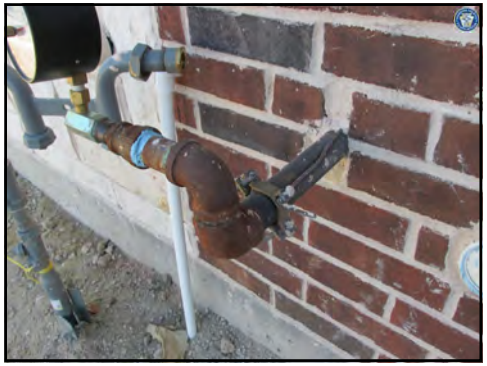
- Metal gas piping system(s) and other metallic piping systems that are likely to become energized are required to be bonded to any of the following:
  - Equipment grounding conductor for the circuit that is likely to energize the piping system
  - Service equipment enclosure
  - Grounded conductor at the service
  - Grounding electrode conductor, if of sufficient size
  - One or more grounding electrodes used *(if GEC or bonding jumper are of sufficient size)*

191

250.104(B) Bonding of Other Piping Systems *(cont.)*

- Bonding conductor(s) or jumper(s) used to bond other piping systems must be sized in accordance with 250.122, using the rating of the circuit that is likely to energize the piping system(s)
- The equipment grounding conductor for the circuit that is capable of energizing the piping is permitted to serve as the bonding means
- The points of attachment of the bonding jumper(s) to be accessible

192



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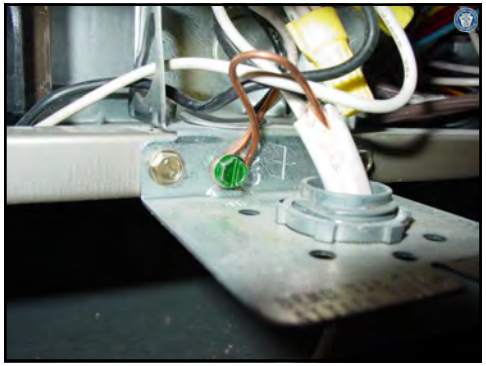


195

Table 250.122 *(in part)*

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding *(Amperes)*	Size *(AWG or kcmil)*	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0

Note: Where necessary to comply with 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.
*See installation restrictions in 250.120

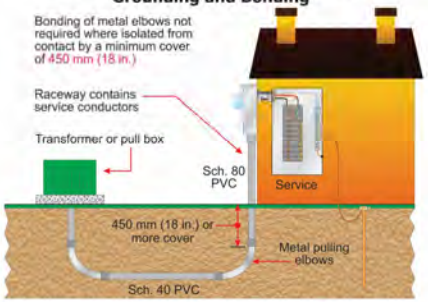
196

250.80 Exception: Service Raceway Grounding and Bonding

- All metal enclosures for service enclosures and equipment required to be connected to the grounded system conductor
- **Metal elbows** and metal components are **exempted** from this bonding that is installed in an **underground installation** of nonmetallic conduit where it is isolated from possible contact by a minimum earth cover of **450 mm (18 in.)** to any part of the elbow or metal component
- Common practice to install **metal elbows for pulling purposes** in an underground service raceway of rigid polyvinyl chloride conduit (PVC) to prevent damaging the PVC raceways during cable pulling operations

197

250.80 Exception: Service Raceway Grounding and Bonding



198

Bonding and Grounding Remote Metering Equipment

- The *Code* requires all equipment containing service conductors to be grounded and bonded *(including meter enclosures)* (*NEC* 250.80; 250.92)
- Important that the grounded service (neutral) conductor be connected to the meter enclosure
- Provides a low-impedance path from any line-to-ground fault that may occur in the remote metering equipment back to the source *(typically utility transformer)*
- The use of the grounded service conductor for bonding equipment on the line side of the service disconnecting means is permitted by the *Code* for this purpose [*NEC* 250.142(A)]

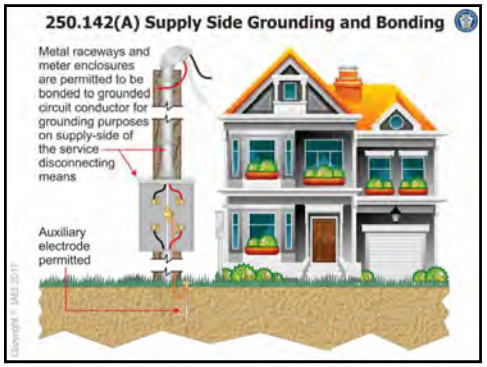
199

Bonding and Grounding Remote Metering Equipment *(cont.)*

- Where a ground rod or other electrode such as a plate or pipe is installed at the remote meter equipment, it is considered a **auxiliary grounding electrode**
- Permitted to be installed in addition to the required safety bonding and grounding connections
- The earth is not permitted to be used as a substitute for a required equipment grounding conductor
- See *NEC* 250.54

200

250.142(A) Supply Side Grounding and Bonding



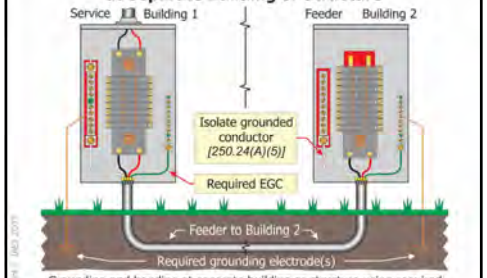
201

Grounding at Separate Buildings or Structures (Outbuildings)

- For **new installations**, feeders and branch circuits to separate outbuildings must employ an **equipment grounding conductor**
- Feeder or branch circuit to the outbuilding must provide a means to ground equipment in the outbuilding ***(EGC with the supply conductors to the outbuilding)***
- Grounded conductor cannot be connected to the EGCs or to the established grounding electrode system at the second building
- Grounding electrode system must be established at the outbuilding if there is no existing grounding electrode system present at the outbuilding
- See *NEC* 250.32(A) and (B)

202

250.32(B)(1) Grounding and Bonding at Separate Building or Structure



Grounding and bonding at separate building or structure using required equipment grounding conductor *(EGC)*

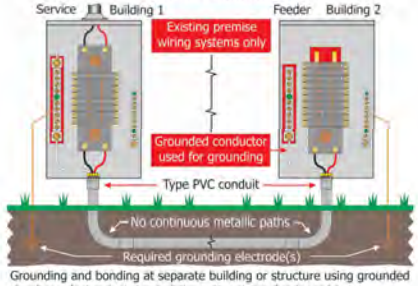
203

Grounding at Separate Buildings or Structures (Outbuildings) *(cont.)*

- Exception to *NEC* 250.32(B) permits the use of grounded (neutral) circuit conductor for grounding at outbuilding *(existing building with existing feeder or branch circuit)*
- Grounded (neutral) conductor permitted to be grounded again at additional building or structure if all the following conditions are met:
  - **No EGC** with supply to the second building or structure
  - **No continuous metallic paths** bonded to the grounding system in each building or structure involved *(metallic wiring method, metallic water or gas lines, phone lines, etc.)*
  - **No Ground-fault protection** of equipment on the common ac service *(not typical for dwelling units)*
- See *NEC* 250.32(B)(1) Ex. No. 1

204

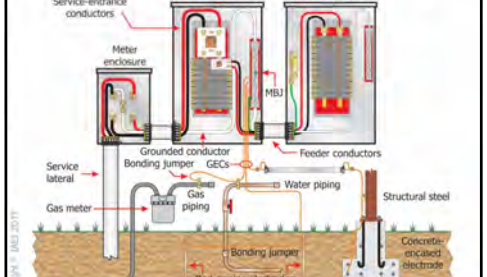
250.32(B)(1) Ex. No. 1 Grounding and Bonding at Separate Building or Structure



Grounding and bonding at separate building or structure using grounded circuit conductor *(existing building with existing feeder only)*

205

Grounding and Bonding for a Dwelling Unit Service



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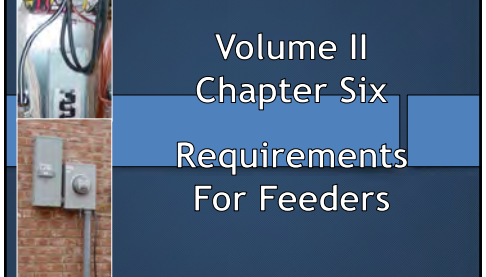


207

Bonding and Grounding Remote Metering Equipment

- The *Code* requires all equipment containing service conductors to be grounded and bonded *(including meter enclosures)* (*NEC* 250.80; 250.92)
- Important that the grounded service (neutral) conductor be connected to the meter enclosure
- Provides a low-impedance path from any line-to-ground fault that may occur in the remote metering equipment back to the source *(typically utility transformer)*
- The use of the grounded service conductor for bonding equipment on the line side of the service disconnecting means is permitted by the *Code* for this purpose [*NEC* 250.142(A)]

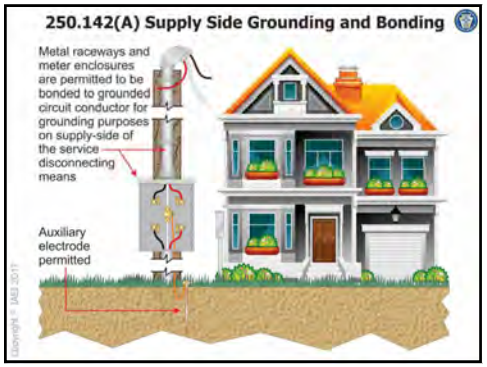
199

Bonding and Grounding Remote Metering Equipment *(cont.)*

- Where a ground rod or other electrode such as a plate or pipe is installed at the remote meter equipment, it is considered a **auxiliary grounding electrode**
- Permitted to be installed in addition to the required safety bonding and grounding connections
- The earth is not permitted to be used as a substitute for a required equipment grounding conductor
- See *NEC* 250.54

200

250.142(A) Supply Side Grounding and Bonding



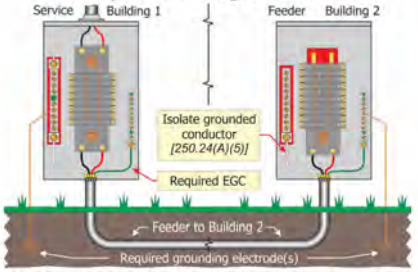
201

Grounding at Separate Buildings or Structures (Outbuildings)

- For **new installations**, feeders and branch circuits to separate outbuildings must employ an **equipment grounding conductor**
- Feeder or branch circuit to the outbuilding must provide a means to ground equipment in the outbuilding ***(EGC with the supply conductors to the outbuilding)***
- Grounded conductor cannot be connected to the EGCs or to the established grounding electrode system at the second building
- Grounding electrode system must be established at the outbuilding if there is no existing grounding electrode system present at the outbuilding
- See *NEC* 250.32(A) and (B)

202

250.32(B)(1) Grounding and Bonding at Separate Building or Structure



Grounding and bonding at separate building or structure using required equipment grounding conductor *(EGC)*

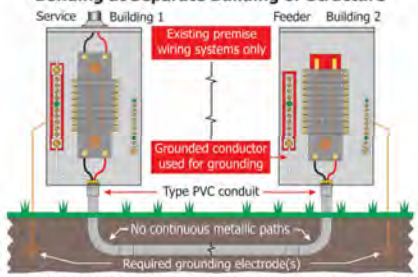
203

Grounding at Separate Buildings or Structures (Outbuildings) *(cont.)*

- Exception to *NEC* 250.32(B) permits the use of grounded (neutral) circuit conductor for grounding at outbuilding *(existing building with existing feeder or branch circuit)*
- Grounded (neutral) conductor permitted to be grounded again at additional building or structure if all the following conditions are met:
  - **No EGC** with supply to the second building or structure
  - **No continuous metallic paths** bonded to the grounding system in each building or structure involved *(metallic wiring method, metallic water or gas lines, phone lines, etc.)*
  - **No Ground-fault protection** of equipment on the common ac service *(not typical for dwelling units)*
- See *NEC* 250.32(B)(1) Ex. No. 1

204

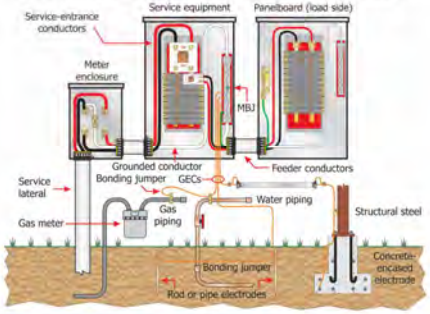
250.32(B)(1) Ex. No. 1 Grounding and Bonding at Separate Building or Structure



Grounding and bonding at separate building or structure using grounded circuit conductor *(existing building with existing feeder only)*

205

Grounding and Bonding for a Dwelling Unit Service



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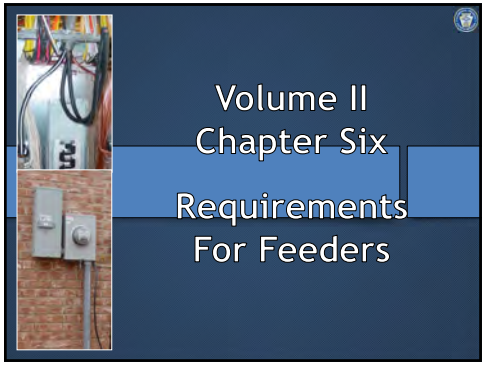


207

208

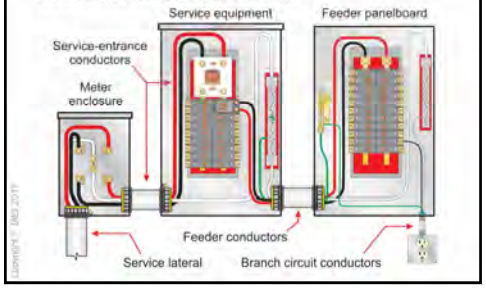
Article 100: Definitions

- **Concealed:** "Rendered inaccessible by the structure or finish of the building."
  - **Informational Note:** Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them.
- **Exposed *(as applied to wiring methods)*:** "On or attached to the surface or behind panels designed to allow access."
- **Feeder:** "All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device."

209

Article 100: Definition - Feeder

Feeder is defined as "all circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch circuit overcurrent device."

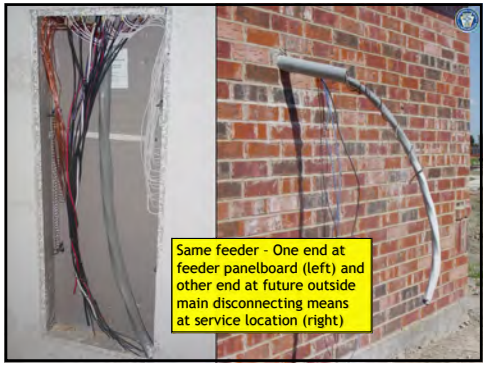


210

Sizing Feeder Conductors

- Feeders must sized to have an ampacity not less than required to supply the loads as calculated in Parts III, IV, and V of Article 220 [215.2(A)(1)]
- Feeder conductors for a dwelling unit or mobile home need not be larger than the service-entrance conductors
- 83 percent ampacity adjustment factor given at 310.15(B)(7) shall be permitted to be used for the "main power feeder"
- Ampacity values for feeders other than the "main power feeder" are derived from Table 310.15(B)(16)

211



212

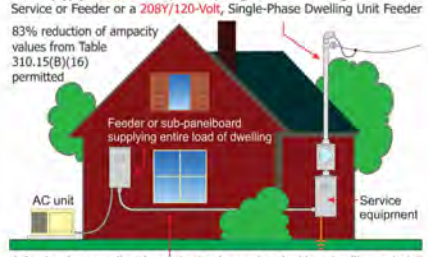
310.15(B)(7) Main Power Feeder

- 310.15(B)(7) permits an **83 percent** adjustment to the ampacity values of Table 310.15(B)(16) to a feeder conductor that serve as the "main power feeder" of a dwelling unit
- For application of this section, the main power feeder shall be the feeder that supplies the entire load of a dwelling unit installed between the main service disconnect and a feeder panelboard *(sub-panelboard)*

213

310.15(B)(7) Main Power Feeder

310.15(B)(7) - 120/240-Volt, 3-Wire, Single-Phase Dwelling Unit Service or Feeder or a 208Y/120-Volt, Single-Phase Dwelling Unit Feeder



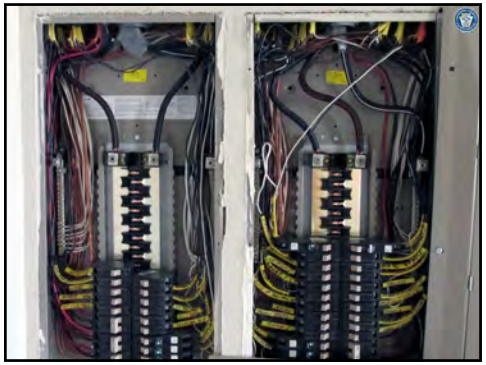
A feeder that supplies the entire load associated with a dwelling unit *(all branch circuits, feeders, or both)* is commonly referred to as the **"Main Power Feeder"** *(feeder not required to be larger than SE conductors)*

214

Feeder Overcurrent Protection

- Feeder conductors are required to be protected against overcurrent *(which includes overload, ground faults and short circuits)* in accordance with the provisions of Part I of Article 240
- Protect conductors against overcurrent in accordance with their ampacities as specified in 310.15, unless otherwise provided [240.4]
- Generally, overcurrent device for dwelling unit feeders must be selected so as to not exceed ampacity of conductors in Table 310.15(B)(16)
- Generally, the overcurrent protection is required to be located at the point where the conductor receives its supply

215



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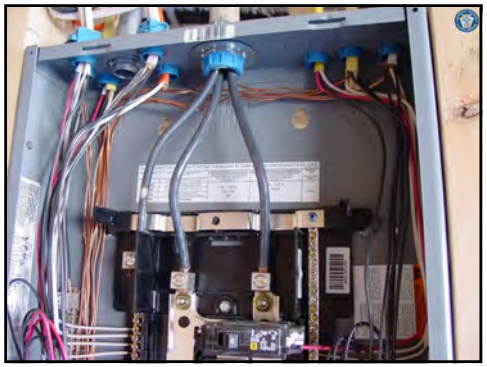
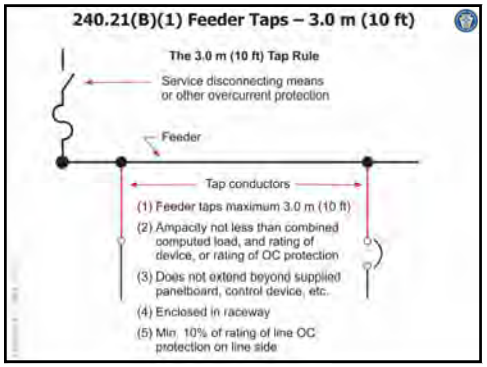


217

Tap Rules for Feeders

- Protect feeders generally at the point where the feeder receives its supply
- Feeder taps permitted in 240.21(B)
  - 3.0 m (10 ft) tap rule [240.21(B)(1)]
  - 7.5 m (25 ft) tap rule [240.21(B)(2)]

218



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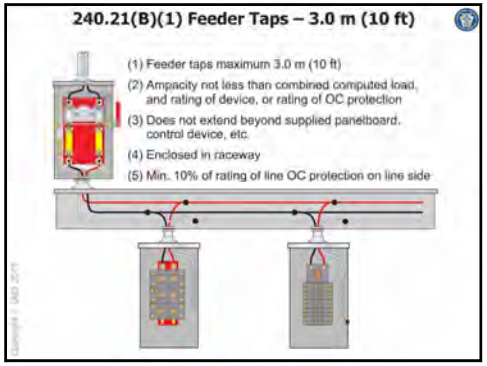

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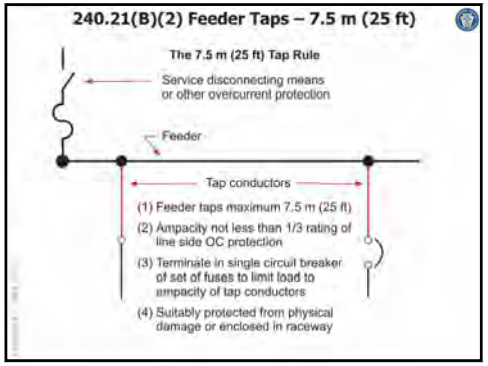

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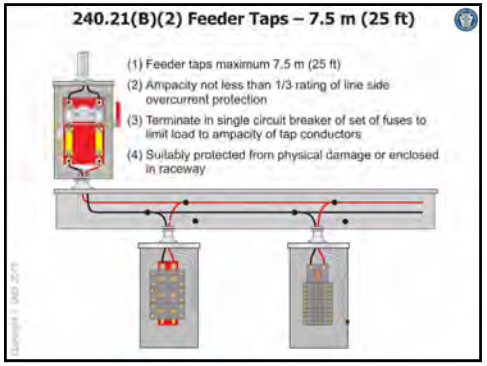
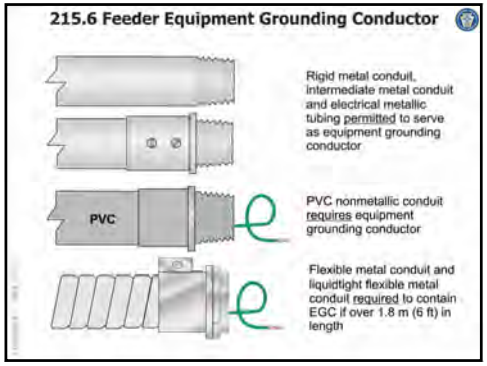


222

Equipment Grounding Conductors

- *NEC* 215.6 requires a feeder supplying branch circuits in which equipment grounding conductors are required, the **feeder must include or provide an EGC** in accordance with 250.134, to which all EGCs of the branch circuits will be connected
- Section 250.134(A) permits any EGC permitted by 250.118
- Section 250.134(B) permits a grounding means by connecting to an EGC contained within the same raceway, cable, or otherwise run with the circuit conductors

223



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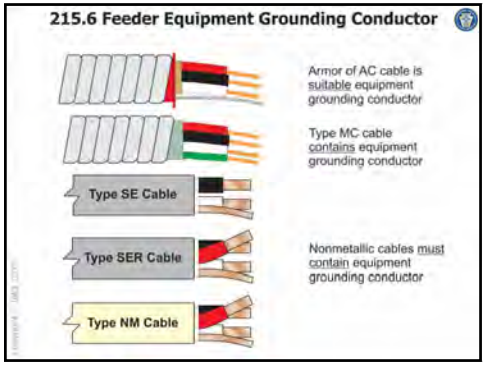

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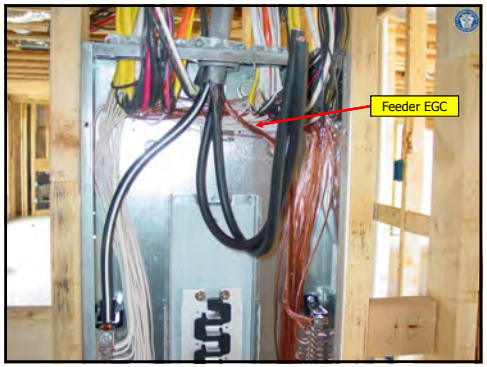


226

250.118 Types of Equipment Grounding Conductors

- Types of EGCs employed with the most commonly used wiring methods at dwelling units:
  - Copper or other corrosion-resistant conductor
  - Rigid metal conduit
  - Intermediate metal conduit
  - Electrical metallic tubing
  - Flexible metal conduit *(specific conditions)*
  - Liquidtight flexible metal conduit *(specific conditions)*
  - Armor of Type AC Cable
  - Type MC Cable listed for grounding
  - Other electrically continuous metal raceways listed for grounding

227

334.108 EGC for Type NM Cable

- In addition to the insulated conductors, Type NM cable shall have an insulated or bare equipment grounding conductor (EGC)
- This equipment grounding conductor shall be sized in accordance with Table 250.122

228

250.119 Identification of EGCs

- Identification of equipment grounding conductor must be by continuous green color, or green with one or more yellow stripes
- EGCs can also be bare, covered, or insulated
- An insulated or covered EGC larger than 6 AWG shall be permitted, at the time of installation, to be permanently identified as an EGC at each end and at every point where the conductor is accessible
- Identification shall encircle the conductor

229

Table 250.122 *(in part)*

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

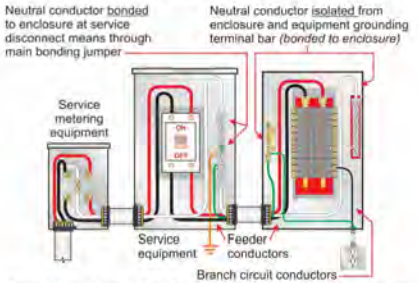
Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding *(Amperes)*	Size *(AWG or kcmil)*	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0

Note: Where necessary to comply with 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.

*See installation restrictions in 250.120

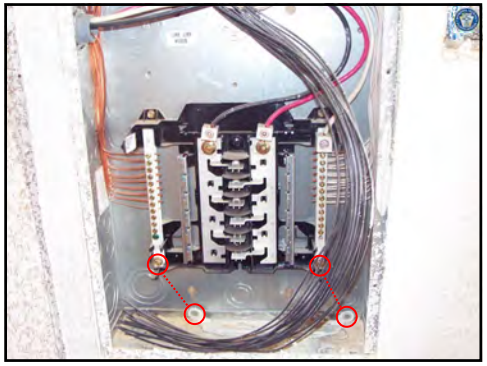
230

250.24(A)(5) Separate Neutrals and Grounds

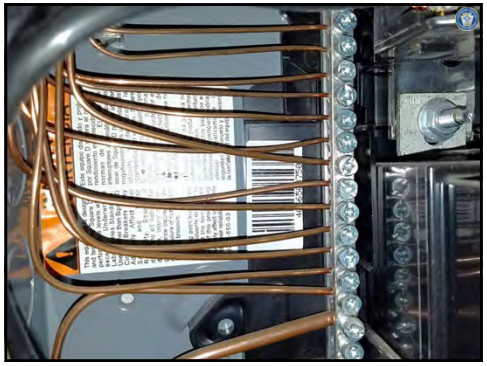


Grounded conductor shall not be used for grounding noncurrent-carrying metal parts of equipment on the load side of service disconnecting means

231



232



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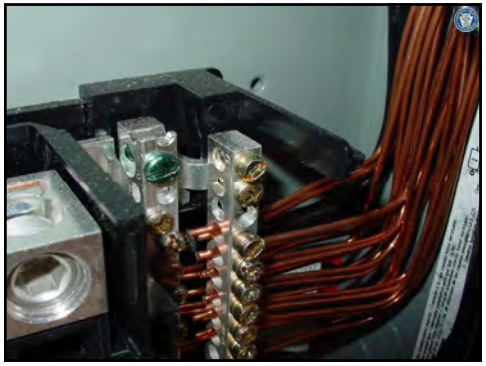
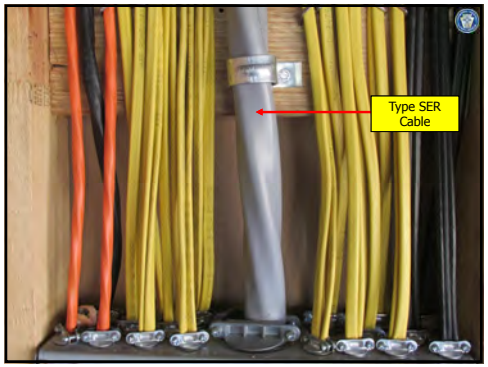


234

Types of Feeder Conductors

- A wide variety of feeder conductors is permitted in dwelling units in the form of both cable and raceways
- Feeders installed in a conduit or as a cable assembly required to include conductors having insulation that is recognized by *NEC* Table 310.104(A)
- Typical feeder cable assemblies may include:
  - Type AC
  - Type NM
  - Type UF
  - Type SER
- Typical raceways used for feeders may include:
  - ENT
  - EMT
  - RMC
  - PVC
  - IMC

235



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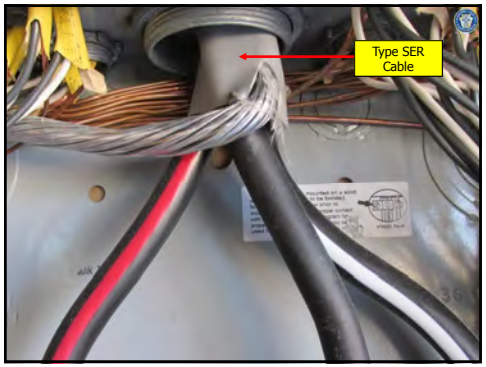
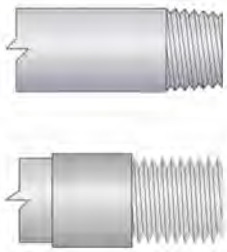


237

Installation Requirements for Raceways



Must be suitable for the environment and conditions where installed

Number of conductors not to exceed maximum fill percentages

Cut ends reamed or otherwise finished to remove rough edges

Field threads: standard cutting die with a taper of 1 in 16 (¾ in. taper per ft)

Running threads not to be used at couplings

See NEC Article 300 and Chapter 3 wiring method articles for more details

238

Minimum Size of Raceways

- Conduit fill requirements are important
- *NEC* 300.17 as well as "XXX.22" of the wiring method articles provides general information relative to the number and size of conductors permitted in raceways
- Limits the build up of heat from current-carrying conductors and minimizes damage to the conductors
- *NEC* Table 1 Chapter 9 provides maximum percentages for conduit fill

Percentage of Fill for Raceways			
Number of Conductors/Cables	1	2	Over 2
Cross-Sectional Area (%)	53%	31%	40%

239

NEC Chapter 9 Tables: Table 1

Table 1: Percent of Cross Section of Conduit and Tubing for Conductors and Cables

Number of Conductors and/or Cables	Cross Sectional Area (%)
1	53%
2	31%
Over 2	40%

240

Informative Annex C Conduit Fill Example

- **What is the minimum size EMT for a 100-ampere feeder using three 4 AWG THHN conductors?**
  - **Step 1.** EMT is the raceway; therefore, Table C.1 applies.
  - **Step 2.** THHN is the insulation type. Follow down the left column until the insulation type THHN is found. Stop at conductor size 4 AWG.
  - **Step 3.** Follow across the columns until the smallest size EMT for 3 conductors is found. Metric designator 21 (¾ in.) is too small. Metric designator 27 (1 in.) will accept 4 conductors.

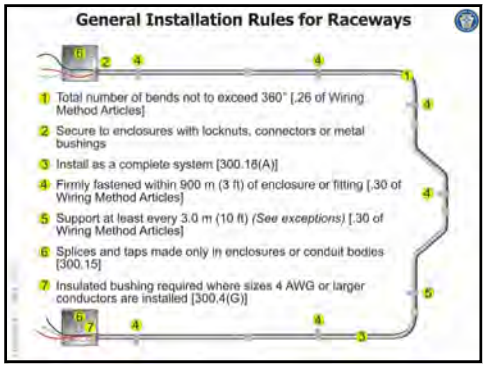
241

Expansion Fittings

- **Expansion fittings** for PVC conduit are required to be provided to compensate for thermal expansion and contraction in a straight run between securely mounted equipment such as boxes, cabinets, elbows, or other conduit terminations
- Applies where the calculated expansion will exceed **6 mm (¼ in.)**
- *NEC* Tables 352.44 give the expansion characteristics of PVC conduit for various temperature changes
- As a rule of thumb, add **30°F** to the expected temperature change for direct sunlight exposure
- Gray PVC conduit has a tendency to absorb the ultraviolet (UV) rays of the sun

242

243



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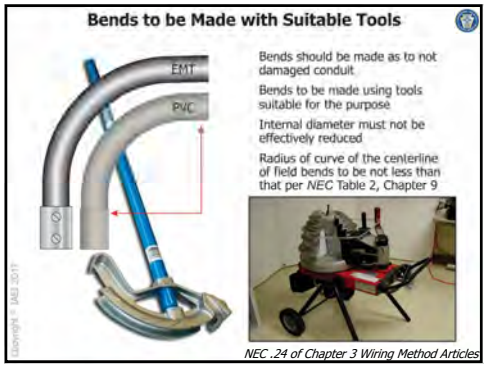

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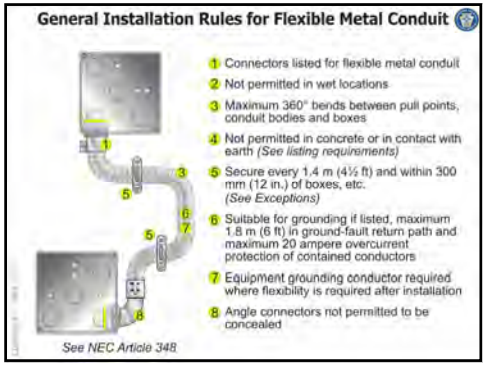

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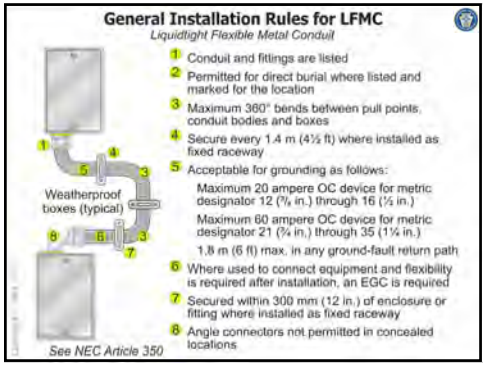

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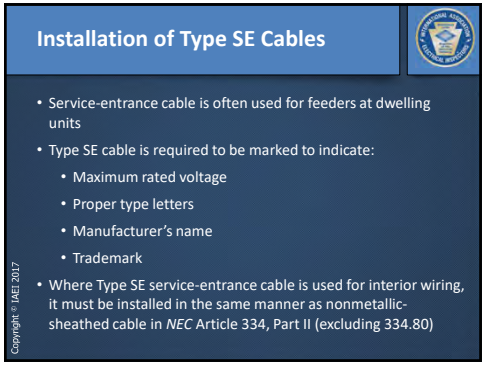


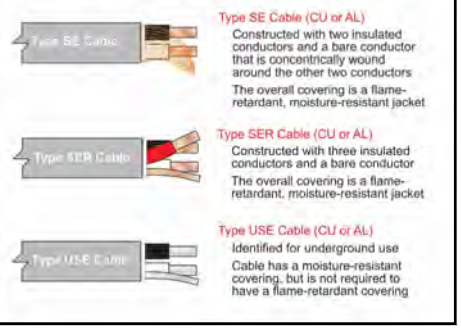
252

Installation of Type SE Cables *(cont.)*

- Type USE conductors are usually limited to installation underground
- This is due to the Type USE insulation not being of flame-retardant construction
- The *Code* permits Type USE cable to rise aboveground as long as it is outside of the building

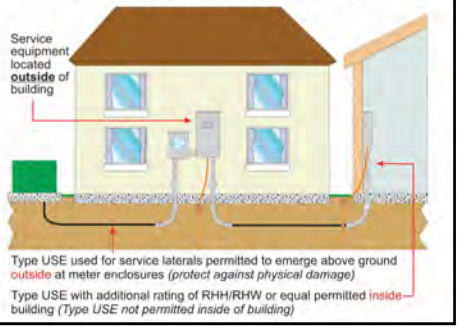
253

Article 338 Service-Entrance Cable



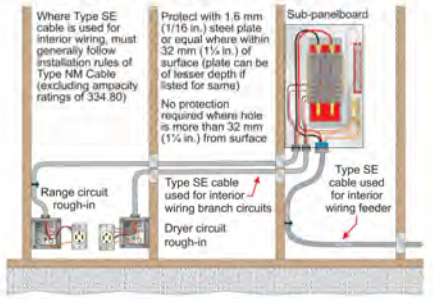
254

338.12(B)(2), 230.41 Type USE Cable



255

338.10(B) Type SE Cable Permitted as Feeders



256

Cables and Electrical Nonmetallic Tubing Through Metal Framing Members

- Where **nonmetallic-sheathed feeder cables** are run exposed or concealed and pass through either factory- or field-punched, cut, or drilled slots or holes in **metal framing members**, the cable assembly must be protected by **bushings or grommets** securely fastened in the opening **before the cable is installed**
- Bushing or grommet required to cover **all metal edges** and it shall be **listed** *(variety of products that meet this requirement)*
- The use of a piece of cardboard or other non-approved material is not acceptable and must not be permitted as damage to the cable could be the result
- See *NEC* 300.4(B)(1)

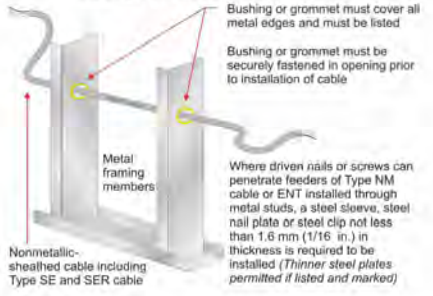
257

Cables and Electrical Nonmetallic Tubing Through Metal Framing Members *(cont.)*

- Where **driven nails or screws** can penetrate feeders of nonmetallic-sheathed cable or electrical nonmetallic tubing installed through 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 protect cable or tubing from possible penetration
- Thinner steel plates permitted here if **listed and marked** appropriately
- Not applicable to Type AC feeder cable assemblies
- See *NEC* 300.4(B)(2)

258

300.4(B) Protection for SE Cables Through Metal Framing Members



259

260

Conduit Bodies

- Requirements for installing **conduit bodies** are found in *NEC* Article 314
- Conduit bodies generally are **not permitted to contain splices** unless they are **durably and legibly marked** with their cubic inch capacity
- If they are marked, **conductor fill** is determined using the same procedure for other than standard boxes
- See *NEC* 314.16(C)(2)

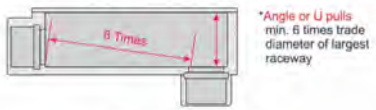
261

Conduit Bodies *(cont.)*

- Conduit bodies that are used as **pull or junction boxes** are required to comply with *NEC* 314.28(A)(1) through (A)(3)
- For **straight-through pulls**, the length of the conduit body normally must not be less than **eight times** the diameter of the largest raceway
- Where used with **angle or U pulls**, the distance between raceway entries and the opposite wall must not be less than **six times** the diameter of the largest conduit
- Dimension can be reduced where the conduit entry is opposite a **removable cover** and that distance is not less than in *NEC* Table 312.6(A) for one conductor per terminal

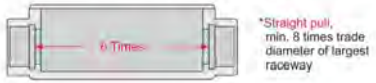
262

314.28(A) Box and Conduit Body Sizes



*Angle or U pulls min. 6 times trade diameter of largest raceway

Applies to pull boxes also for conductors in sizes 4 AWG or larger



*Straight pull, min. 8 times trade diameter of largest raceway

*Unless conduit body is marked with maximum size and number of conductors

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Chapter Seven
Requirements for Major Household Appliances

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Article 100: Definitions

- **Appliance:** "Utilization equipment, generally other than industrial, that is normally built in standardized sizes or types and is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, and so forth."
- **Utilization Equipment:** "Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes."

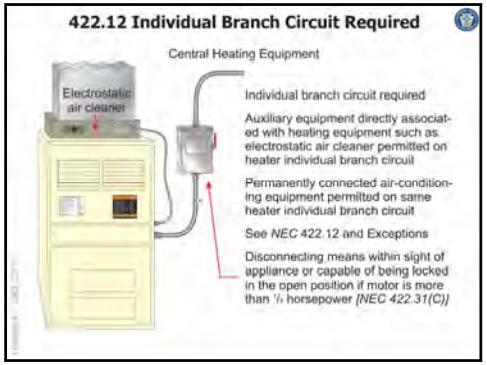
266

Branch Circuit Requirements for Appliances

• Rating of branch circuit	422.10
• Individual branch circuit	422.10(A)
• Circuits supplying two or more loads	422.10(B)
• Branch-circuit overcurrent protection	422.11
• Individual branch circuit required	422.12 *(central heating equipment)*
• Disconnecting means within sight	422.31(C) *(motor-operated appliance rated over ⅛ hp)*

267

422.12 Individual Branch Circuit Required



268

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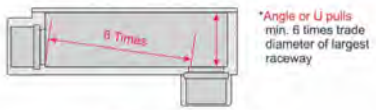
270

Conduit Bodies *(cont.)*

- Conduit bodies that are used as **pull or junction boxes** are required to comply with *NEC* 314.28(A)(1) through (A)(3)
- For **straight-through pulls**, the length of the conduit body normally must not be less than **eight times** the diameter of the largest raceway
- Where used with **angle or U pulls**, the distance between raceway entries and the opposite wall must not be less than **six times** the diameter of the largest conduit
- Dimension can be reduced where the conduit entry is opposite a **removable cover** and that distance is not less than in *NEC* Table 312.6(A) for one conductor per terminal

262

314.28(A) Box and Conduit Body Sizes



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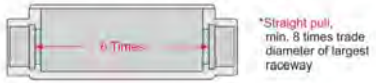
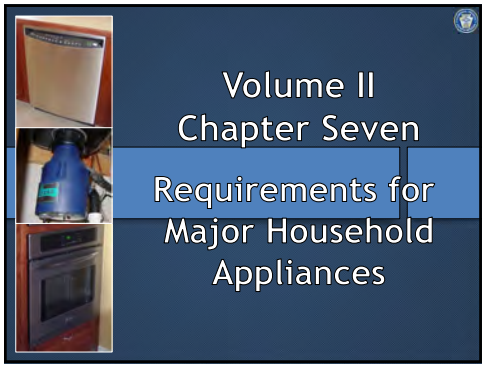


*Straight pull, min. 8 times trade diameter of largest raceway

*Unless conduit body is marked with maximum size and number of conductors

263



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265

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266

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• Individual branch circuit	422.10(A)
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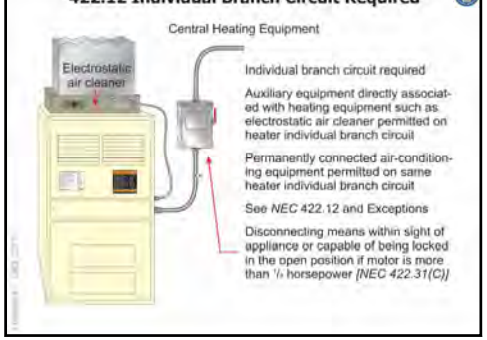
• Disconnecting means within sight	422.31(C) *(motor-operated appliance rated over ⅛ hp)*

267

422.12 Individual Branch Circuit Required



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422.16 Appliances Connected with Flexible Cords

- Flexible cords permitted to be used for the connection of some appliances
- Flexible cord permitted to facilitate frequent interchange or to prevent the transmission of noise or vibration to an appliance *(such as a sump pump)*
- Flexible cord is also permitted to be used to facilitate the removal or disconnection of appliances that are fastened in place - appliance must be specifically identified for a flexible cord connection *(such as range, dishwasher, etc.)*
- Central heating appliances and electric water heaters are not permitted to be cord-and-plug-connected *(flexible cords typically not listed for heating appliance)*

271

422.16(A) Use of Flexible Cords Limited

Cord-and-Plug Connection Not Permitted

Cord-and-plug connection prohibited unless fastening means and mechanical connections are specifically designed to permit ready removal for maintenance or repair, and the appliance is intended or identified for flexible cord connection

272

422.16(B) Appliances Connected with Flexible Cords

- Some appliances are specifically permitted to be cord-and plug-connected even though they are not portable appliances
- The attachment plugs must be of the grounding-type
- Specific appliances permitted to be cord-and-plug connected [422.16(B)]:
  - Kitchen waste disposers
  - Dishwashers
  - Trash compactors
  - Ovens and ranges
  - Range vent-a-hoods

273

422.16(B) Flexible Cords Permitted

Specific appliances permitted to be connected with a flexible cord
Receptacles required to be accessible
Flexible cords "identified for the purpose" (typical)

274

275

422.16(B)(1) Wiring of In-Sink Kitchen Waste Disposal

- Permitted to be cord-and-plug connected
- Flexible cord shall be terminated with a grounding-type attachment plug
- Length - 450 mm (18 in.) to 900 mm (36 in.)
- Flexible cord and receptacle not to be subject to physical damage
- Connection required to be accessible

276

277

422.16(B)(2) Wiring of Built-in Dishwasher

- Permitted to be cord-and-plug connected
- Flexible cord shall be terminated with a grounding-type attachment plug
- Length – 900 mm (36 in.) to 2.0 m (6.5 ft)
- Flexible cord and receptacle not to be subject to physical damage
- Receptacle to be located in the space adjacent to the appliance
- Receptacle required to be accessible

278

422.16(B)(2) Built-In Dishwashers

Receptacle outlet for cord-and-plug connected built-in dishwasher required to be located in the space adjacent to the space containing the dishwasher with the length of a cord for a built-in dishwasher permitted to be 0.9 m (3 ft) to 2.0 m (6½ ft) in length

279

422.16(B)(2) Wiring of Trash Compactor

- Permitted to be cord-and-plug connected
- Flexible cord shall be terminated with a grounding-type attachment plug
- Length – 900 mm (36 in.) to 1.2 m (4 ft)
- Flexible cord and receptacle not to be subject to physical damage
- Receptacle to be located in same space as appliance or adjacent space to the appliance
- Receptacle required to be accessible

280

422.16(B)(4) Wiring of Range Hoods

- Permitted to be cord-and-plug connected
- Flexible cord shall be terminated with a grounding-type attachment plug
- Length – 450 mm (18 in.) to 1.2 m (4 ft)
- Flexible cord and receptacle not to be subject to physical damage
- Receptacle required to be accessible
- Receptacle supplied by an individual branch circuit

281

422.16(B)(4) Range Hoods

Range hoods permitted to be cord-and-plug connected where identified on installation instructions by manufacturer and meets the following:

Maximum length of cord for cord-and-plug connected range hoods has been increased from 900 mm (36 in.) to 1.2 m (4 ft)

282

283

Wall-Mounted Ovens and Counter-Mounted Cooking Units

- Wall-mounted ovens and counter-mounted cooking units are permitted to be either permanently connected or cord-and-plug connected
- No minimum or maximum length of the cord for this type of appliance
- The cord, the separable connector, or plug and receptacle combination in the supply circuit to the oven or cooking unit shall be suitable for the **maximum temperature** of the space in which it is located *(consult manufacturer's installation instructions)*

284

Wall-Mounted Ovens and Counter-Mounted Cooking Units *(cont.)*

- The *Code* prohibits the use of flexible cords where they will run through holes in walls, structural ceilings, suspended ceilings, dropped ceilings, or floors
- Flexible cord permitted to pass through a hole in the side of a kitchen cabinet in order to reach a receptacle outlet located in an adjacent cabinet *(side of a kitchen cabinet is not a wall)*
- Flexible cord must be protected from physical damage
- Generally, grounding-type attachment plug is required

285

286

422.18 Support of Ceiling-Suspended (Paddle) Fans

- Ceiling-suspended (paddle) fans is considered an appliance
- Must be **supported independent** of an outlet box by one of the following means:
  - A **listed outlet box** or **listed outlet box system** identified for use with a ceiling-suspended (paddle) fan and installed to meet the requirements of *NEC* 314.27(C)
  - A listed outlet box system with a **listed locking support and mounting receptacle**, and a compatible factory installed **attachment fitting** designed for support, identified for the use and installed in accordance with *NEC* 314.27(E)

287

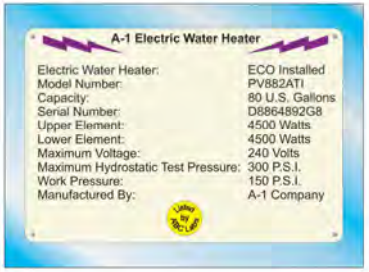
288

422.13 Wiring of Electric Water Heaters

- Where a branch circuit supplies a fixed storage-type water heater having a capacity of 120 gallons or less, load to be considered a **continuous load**
- Branch circuit required to be rated at not less than **125%** of the rating of the water heater shown on the nameplate
- This includes both the overcurrent device [422.11] and the conductors [422.10(A)]

289

Typical Electric Water Heater Nameplate



290

422.13 Wiring of Electric Water Heaters *(cont.)*

- Branch-Circuit Ampacity Example:
  - Nameplate rating = 4500 watts
  - 4500 watts x 125% = 5625 watts
  - 5625 watts ÷ 240 volts = 23.4 amperes
  - **23.4 amperes** = Minimum ampacity for branch-circuit conductors

291

422.11 OCPD for Electric Water Heaters

- Overcurrent Protection Example:
  - Nameplate rating = 4500 watts
  - 4500 watts ÷ 240 volts = 18.8 amperes
  - 18.8 amperes x 150% = 28.2 amperes *[422.11(E)(3)]*
  - Permitted to round up to next standard overcurrent device rating *[422.11(E)(3)]*
  - Minimum overcurrent device = **30 ampere** fuse or circuit breaker

292

422.31 Disconnecting Means for Appliances

- Disconnecting means are generally required for all appliances to disconnect all ungrounded conductors
- 422.31(A) Rated at **Not Over 300 VA or ¼ hp**
  - Branch-circuit overcurrent device permitted as disconnecting means with…
    - Switch or circuit breaker within sight from appliance or…
    - Capable of being locked in accordance with 110.25
- Locking device must remain in place with or without the lock installed

293

422.31 Disconnecting Means for Appliances *(cont.)*

- Disconnecting means are generally required for all appliances to disconnect all ungrounded conductors
- 422.31(B) Rated at **Over 300 VA**
  - Branch-circuit switch or circuit breaker is permitted as the disconnecting means where…
    - Switch or circuit breaker within sight from appliance or…
    - Capable of being locked in accordance with 110.25
- Locking device must remain in place with or without the lock installed

294

422.31 Disconnecting Means for Appliances *(cont.)*

- Disconnecting means are generally required for all appliances to disconnect all ungrounded conductors
- 422.31(C) Motor-Operated Rated **Over ⅛ hp**
  - Disconnecting means must be:
    - Within sight from appliance or…
    - Capable of being locked in accordance with 110.25
  - Locking device must remain in place with or without the lock installed
  - Branch-circuit switch or circuit breaker is permitted to be out of sight of the appliance *(with **unit switch**)*

295

422.31 Disconnecting Means Required

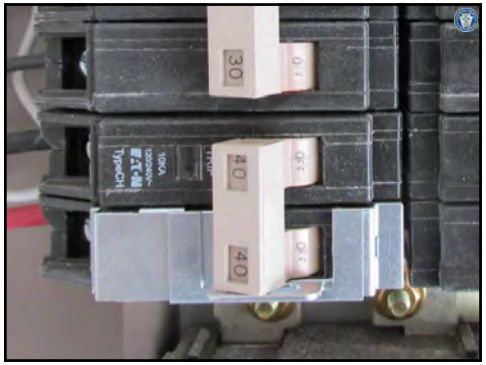
Permitted disconnecting means for appliances where located within sight of the appliance or capable of being locked in the open position:

Not over 300 watts or ¼ hp - branch-circuit OCPD

Over 300 watts - branch-circuit switch or circuit breaker

Over ¼ hp - branch-circuit switch or circuit breaker *(permitted to be located out of sight of the appliance with unit switch on the appliance)*

296



297

422.34
Unit Switch as Disconnecting Means

- Unit switch *(on appliance)* permitted as the required disconnect where other means of disconnection is provided
  - (*Service disconnecting means can serve as "other disconnecting means" at one- and two-family dwellings*)
- Switch is provided by the manufacturer as part of the appliance
- Unit switch has a marked "off" position
- Switch disconnects all ungrounded (hot) conductors

298

299

422.11 Overcurrent Protection for Appliances

- Appliances are required to be protected against overcurrent
- The limits on the maximum size of the OCPD are based upon the type of appliance and the information provided on the nameplate
- If an OCPD rating is marked on the appliance, the branch-circuit OCPD rating can not exceed the protective device rating marked on the appliance

300

422.11 Overcurrent Protection for Appliances *(cont.)*

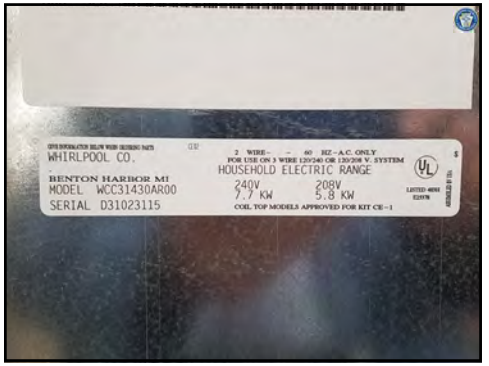
- Appliances with **Surface Heating Elements**:
  - A household-type appliance provided with surface heating elements having a maximum demand of **more than 60 amperes** is required to have its power supply subdivided into two or more circuits
  - Each subdivided circuit is to be provided with overcurrent protection rated at not over 50 amperes
  - *(Subdivision of circuit is not common in household-type appliances)*
- See 422.11(B)

301

422.11 Overcurrent Protection for Appliances *(cont.)*

- **Single, Non-Motor-Operated Appliances**:
  - Rating of OCPD must not be in excess of that marked on the appliance nameplate
  - If the OCPD rating is not marked on the nameplate and the appliance is rated at **over 13.3 amperes**, overcurrent protection cannot exceed **150%** of the appliance rated current *(next higher standard size rating permitted)*
  - If the OCPD rating is not marked and the appliance is rated **13.3 amperes or less**, the maximum rating of the OCPD is **20 amperes** *(lower values are permitted)*
- See 422.11(E)

302



303

422.11 Overcurrent Protection for Appliances *(cont.)*

- Electric Heating Appliances with **Heating Elements Rated More than 48 Amperes**:
  - Must have their heating elements subdivided
  - Each subdivided load cannot exceed **48 amperes** and is required to be protected at not more than **60 amperes**
  - Supplementary-type overcurrent protective devices are permitted to be used for this application *(cont. on next slide)*
- See 422.11(F)(1)

304

422.11 Overcurrent Protection for Appliances *(cont.)*

- Electric Heating Appliances with **Heating Elements Rated More than 48 Amperes**: *(cont.)*
  - Supplementary-type overcurrent protective devices are permitted to be used for this application
  - Supplementary OCPD are required to be:
    - (1) factory installed within or on the heater enclosure, or provided as a separate assembly by the heater manufacturer
    - (2) accessible, but need not be readily accessible
    - (3) suitable for branch-circuit protection
- See 422.11(F)(1)

305

422.11 Overcurrent Protection for Appliances *(cont.)*

- **Resistance-type immersion electric heating elements**:
  - Permitted to be subdivided into circuits not exceeding **120 amperes** and protected at not more than **150 amperes** where:
    - (1) contained in ASME-rated and stamped vessels
    - (2) included in listed instantaneous water heaters
    - (3) installed in low-pressure water heater tanks or open-outlet water heater vessels
- See 422.11(G)

306

422.11 Overcurrent Protection for Appliances *(cont.)*

- **Motor-Operated Appliances**:
  - Overload protection for the motors of motor-operated appliances must be provided per Part III of Article 430
  - In many cases, the manufacturer builds this overload protection into the appliance
  - Where separate motor-operated appliance OCPD are required, information for selection of these devices must be marked on the appliance nameplate
- See 422.11(G)

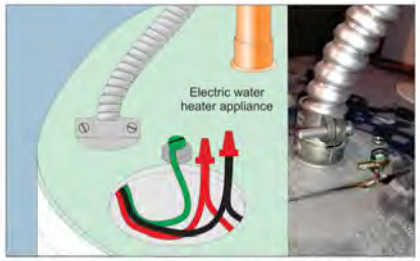
307

250.110 Grounding of Appliances

- Dwelling unit appliances must be **properly grounded** by connection to an **equipment grounding conductor** under the following conditions:
  - Where located within 2.5 m (8 ft) vertically or 1.5 m (5 ft) horizontally of earth grade or grounded metal objects and subject to contact by persons
  - Where located in wet or damp locations *(not isolated)*
  - Where in electrical contact with metal
  - Where supplied by a metal-clad, metal-sheathed, metal-raceway or other wiring method that provides an equipment grounding conductor

308

250.110 Grounding of Appliances



Exposed, normally non-current-carrying metal parts of appliances *(fixed equipment)* that are likely to become energized must be properly grounded by connection an equipment grounding conductor

309

Types of Equipment Grounding Conductors for Appliances

- The type of EGC used to ground appliances will depend on the type of wiring method employed
  - **Cable wiring systems** – EGC typically contained in the cable
  - **Metal-clad cable** – metal cable jacket may qualify and serve as EGC
  - **Metal raceways** – metal raceway itself permitted as EGC
  - **Nonmetallic raceways** – EGC must be installed inside raceway
  - **Cord- and plug-connected equipment** may be grounded by EGC consisting of a bare conductor or insulated conductor that is green or green with one or more yellow stripes that is part of a cable assembly or flexible cord
- See *NEC* 250.118

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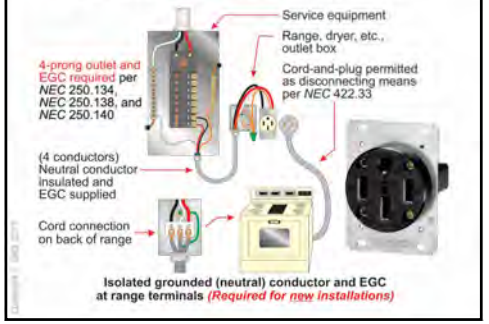
312

Grounding of Cooking Appliances and Clothes Dryers

- **New Installations**:
  - Frames of ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers required to be grounded by connection to an equipment grounding conductor (EGC)
  - Outlet or junction boxes that are part of the circuit must be grounded in a similar manner
  - For a typical 120/240-volt, single-phase dwelling unit system – **(4) conductors** to these appliances
  - For cord- and plug-connected equipment, the EGC will typically terminate in a grounding type attachment plug with a fixed grounding contact

313

250.140 Grounding of New Appliances



314

315

Grounding of Cooking Appliances and Clothes Dryers *(cont.)*

- **Existing Installations**:
  - For **existing branch-circuit installations only** where an EGC is not present, the frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers are permitted to be connected to the grounded circuit conductor if all the following conditions are met:
    - (1) Supply circuit is 120/240-volt, single-phase, 3-wire; or 208Y/120-volt derived from a 3-phase, 4-wire, wye-connected system
    - (2) Grounded conductor is not smaller than 10 AWG copper or 8 AWG aluminum

(cont. on next slide)

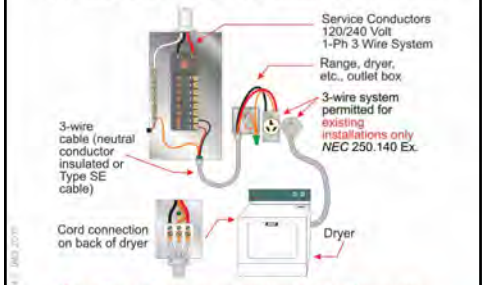
316

Grounding of Cooking Appliances and Clothes Dryers *(cont.)*

- **Existing Installations**: *(cont.)*
  - For **existing branch-circuit installations only** where an EGC is not present, the frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers are permitted to be connected to the grounded circuit conductor if all the following conditions are met:
    - (3) Grounded conductor insulated, or the grounded conductor is uninsulated and part of a Type SE service-entrance cable and the branch circuit originates at the service equipment
    - (4) Grounding contacts of receptacles furnished as part of the equipment are bonded to the equipment

317

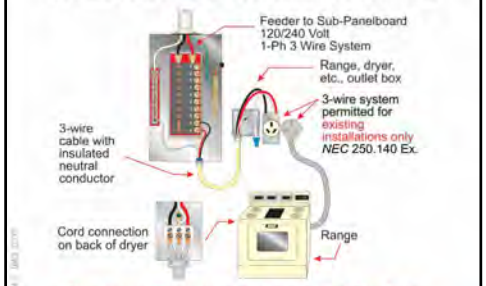
250.140, Ex. Grounding of Existing Appliances



Grounding appliances on existing branch circuit from service

318

250.140, Ex. Grounding of Existing Appliances



Grounding appliances on existing branch circuit from feeder

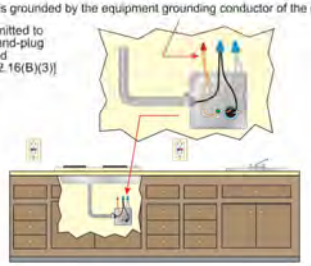
319

250.134(A) Counter-Mounted Cooking Units

Typical counter-mounted cooking units *(cooktops)* are wired using a two-wire (with ground) cable or circuit *[no grounded (neutral) conductor required]*

Cooktop is grounded by the equipment grounding conductor of the circuit

Also permitted to be cord-and-plug connected [*NEC* 422.16(B)(3)]



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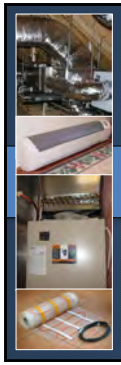

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Fixed Electric Space-Heating Equipment

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File Attachments for Item:

ER-3 Soares Grounding and Bonding (2017 NEC) (IAEI Central)

All certifications (five 2-hour sessions)

Staff Notes: The five sessions include two sessions presented on January 12 and March 9, for which retroactive approval is sought. The Committee can ignore the two sessions listed for the year 2024. They will be submitted at the proper time.

ESIAC Recommendation: Recommend approval

Committee Recommendation:

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: International Association of Electrical Inspectors (IAEI) Central Ohio division

Organization: International Association of Electrical Inspectors (IAEI) Central Ohio division

Address: 1081 Lewis Center Road Lewis Center, OH 43035

E-mail: lettherebelight110@yahoo.com Telephone: 937-763-6361

Website:

Conference Sponsor (if applicable) Conference Email:

Check here if Course Renewal: ☐ Prior course number (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 1 & 2 Family Dwelling (2017 NEC), Soares Grounding and bonding (2017 NEC).

Course instructor: Eric M. Klintworth PE; Matthew Ross; Chad Roberts

Course description: These classes will cover the 2017 NEC; via PowerPoint slides created by t of Electrical Inspectors (IAEI)

Instructional hours per session: 2 hours ea. Number of Sessions: 10; 13 if able to backd

Course Date(s) and Location: 1/12, 2/9, 3/9, 4/13, 5/11, 6/8, 9/14, 10/12, 11/9, & 12/14/2023; 1/11
1081 Lewis Center Road Lewis Center, OH 43035

Special Content:

Code Administration: ☐
Existing Buildings: ☐
Electrical Instruction: ☑
Plumbing Instruction: ☑

Conference Course:
Conference Name:
Conference location:

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website:

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ☐
Administrative Course, All Certifications: ☐

Application materials included:

☐ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

IAEI Central Ohio Division 2023-2024 syllabus

1. January 12, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 4 Grounding Electrical Services. Instructor, Matthew Ross.
2. February 9, 2023
    1. 1 & 2 Family (2017 NEC) (Vol I) Chapter 3. Instructor, Eric Klintworth.
3. March 9, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 5 Main bonding Jumpers and Services. Instructor, Matthew Ross.

The above classes have already been taught if it is possible to backdate to get credit for these classes, that would be great. If not, I understand. We have an attendance roster for verification.

4. April 13, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 6 Grounding Electrode Systems. Instructor, Matthew Ross.
5. May 11, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 4. Instructor, Eric Klintworth.
6. June 8, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 5. Instructor, Eric Klintworth.
7. September 14, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 7 Grounding Electorde Conductors. Instructor, Matthew Ross.
8. October 12, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 6. Instructor, Eric Klintworth.
9. November 9, 2023
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 8 Bonding Enclosures and Equipment. Instructor, Matthew Ross.
10. December 14, 2023
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 7. Instructor, Eric Klintworth.
11. January 11, 2024
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 9 Equipment Grounding Conductors. Instructor, Matthew Ross.
12. February 8, 2024
    1. 1 & 2 Family (2017 NEC) (Vol II) Chapter 8. Instructor, Eric Klintworth.
13. March 14, 2024
    1. Soares 2017 NEC Part 1 (Final) 2--Chapter 10 Enclosure and Equipment Grounding. Instructor, Matthew Ross.

Matthew E. Ross

1000 Township Road 3475 - Perrysville, Ohio 44864
419-512-5025
metdross@hotmail.com

Education

1988 | Loudonville High School

Loudonville High School - 421 Campus Ave. - Loudonville, Ohio 44842

2004 | Journeyman Electrician

Associated Builders and Contractors, Northern Ohio Chapter - 9255 Market Place West - Broadview Heights, Ohio 44147

Professional Certifications and Licenses

2003 | Fire Alarm Installation and Testing

Division of State Fire Marshal - 8895 E. Main St. - Reynoldsburg, Ohio 43068

2006 | Electrical Safety Inspector

Ohio Board of Building Standards - 6606 Tussing Rd. - Reynoldsburg, Ohio 43068

2007 | Electrical Contractor

Ohio Construction Industry Licensing Board - 6606 Tussing Rd. - Reynoldsburg, Ohio 43068

2009 | Residential Building Official

Ohio Board of Building Standards - 6606 Tussing Rd. - Reynoldsburg, Ohio 43068

2010 | Building Inspector

Ohio Board of Building Standards - 6606 Tussing Rd. - Reynoldsburg, Ohio 43068

2014 | Electrical Plans Examiner

Ohio Board of Building Standards - 6606 Tussing Rd. - Reynoldsburg, Ohio 43068

2015 | Building Official

Ohio Board of Building Standards - 6606 Tussing Rd. - Reynoldsburg, Ohio 43068

Experience

07/1996 – 10/1998 | General Construction Worker

Johnson and Johnson Construction - 7342 Armstrong Rd. - Butler, Ohio 44822

Job responsibilities included but were not limited to general construction of steel frame buildings for residential, agricultural, and commercial applications.

10/1998 – 11/2000 | Cabinetmaker

Self Employed (Posse Isle Wood Works) - 1014 Twp. Rd. 3475 - Perrysville, Ohio 44864

Job responsibilities included but were not limited to general woodworking and cabinetry for use in residential and commercial applications.

11/2000 – 04/2002 | Electrician

Clark-Fowler Electric - 510 W. Henry St. - Wooster, Ohio 44691

Job responsibilities included but were not limited to the installation and service of power, control, and signaling systems in residential, commercial, and industrial applications.

04/2002 – 02/2007 | Electrician

Carter Electric, Inc. - 844 Edwards St - Galion, Ohio 44833

Job responsibilities included but were not limited to the installation and service of power, control, and signaling systems in residential, commercial, and industrial applications.

03/2007 – 07/2013 | Electrical Inspector, Chief Building Inspector

Galion Building and Zoning Department - 301 Harding Way East - Galion, Ohio 44833

Job responsibilities included but are not limited to the enforcement of regulations and policy related to property and structures such as commercial and residential construction, zoning, property maintenance, flood plain administration, and nuisance abatement.

07/2013 – 09/2016 | Building/Electrical Inspector

Wayne County Building Department – 428 W. Liberty St. – Wooster, Ohio 44691

Job responsibilities included but are not limited to the enforcement of regulations and policy related to commercial and residential construction.

09/2016 - Present | Building Inspector, Electrical Inspector

City of Dublin - Building Standards Division – 5200 Emerald Pkwy, Annex – Dublin, Ohio 43017

Job responsibilities include but are not limited to the enforcement of regulations and policy related to commercial and residential construction.

Chapter Four:
Grounding Electrical Services

- Important requirements for grounding electrical services
- Proper location of service grounding connection
- Rules for low-impedance grounding electrode connections
- Grounded conductor /dwelling unit services and feeders
- Proper sizing of grounded service conductor
- Rules for parallel service conductors
- Rules for multiple services to one building
- Rules for high-impedance grounded systems
- Grounding rules for instrument transformers, relays, etc.
- Hazards of services from grounded systems without grounded conductor

Grounding Electrical Services

- Electrical services are furnished to the premises by the serving utility as either **grounded** or **ungrounded**
- At the service disconnecting means, system is one of the following:
  - Solidly grounded
  - Ungrounded
  - Resistance or reactance grounded

Grounding Electrical Services *(cont.)*

- How the services are grounded depends on:
  - Type of system installed
  - Design criteria
  - *Code* rules
  - How the utility grounded the supply system

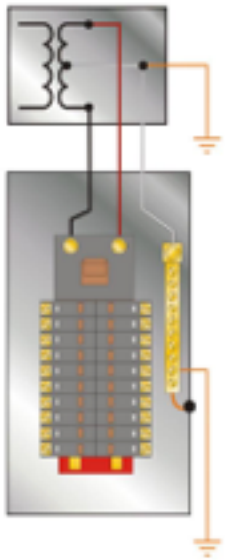
Definitions

- ***Grounded Conductor:*** A system or circuit conductor that is intentionally grounded.
- ***Service:*** The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

Grounded Conductor Size and Routing

- Shall be routed with service-entrance phase conductors
- Shall be connected to the grounded conductor terminal and bonded to service disconnecting means enclosure through the main bonding jumper
- Shall be sized to carry the load per 220.61
- Grounded conductor is not required to be larger than the largest ungrounded service-entrance phase conductor
- For high-impedance grounded neutral systems, see 250.36 for grounded conductor installation and sizing requirements
- Grounded conductor of a 3-phase, 3-wire delta service to have an ampacity not less than ungrounded conductors
- See 250.24(C)

250.24(C) Grounded Conductor Brought to Service

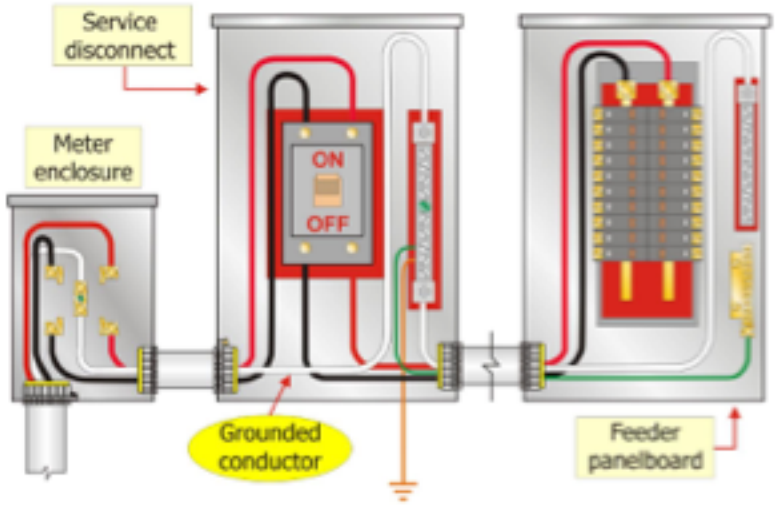


Grounded service conductor of 1000 V or less must be:

1. Routed with phase conductors
2. Run to each service disconnecting means
3. Connected to the grounded conductor terminal and bonded to service disconnecting means enclosure through the main bonding jumper
4. Sized no smaller than grounding electrode conductor
5. Sized at least 12½ percent of area of conductors where larger than given in Table 250.102(C)(1)
6. Based on equivalent area of ungrounded parallel service-entrance conductors
7. Installed in parallel where service is installed in parallel in two or more raceways
8. Must not have an ampacity rating less than the ungrounded conductor of a 3-phase, 3-wire delta service
9. Sized in accordance with minimum service neutral load requirements of 220.61

Grounded Conductor Run to Each Service Disconnect

The grounded conductor(s) is required to be brought to the grounded conductor terminal bus at each service disconnecting means and bonded to each service disconnecting means enclosure using a main bonding jumper [250.24(C)]

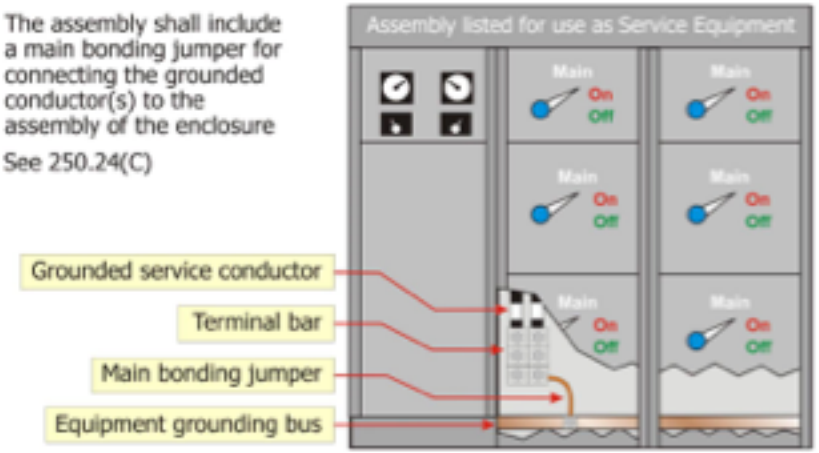


Grounded Conductor to Service Equipment

Where two or more service disconnecting means are located in a single assembly listed for use as service equipment, it shall be permitted to connect the grounded conductor(s) to the assembly common grounded conductor(s) terminal or bus

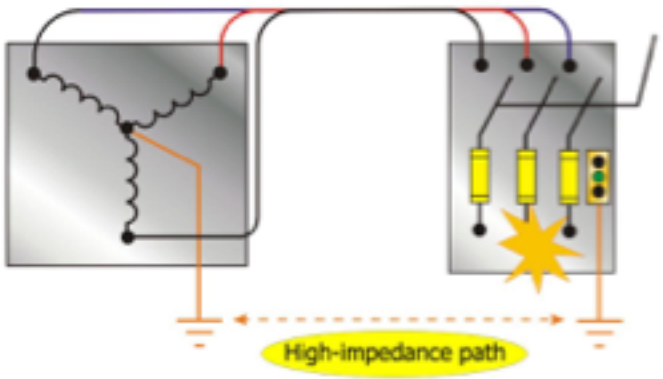
The assembly shall include a main bonding jumper for connecting the grounded conductor(s) to the assembly of the enclosure

See 250.24(C)



High-Impedance Path

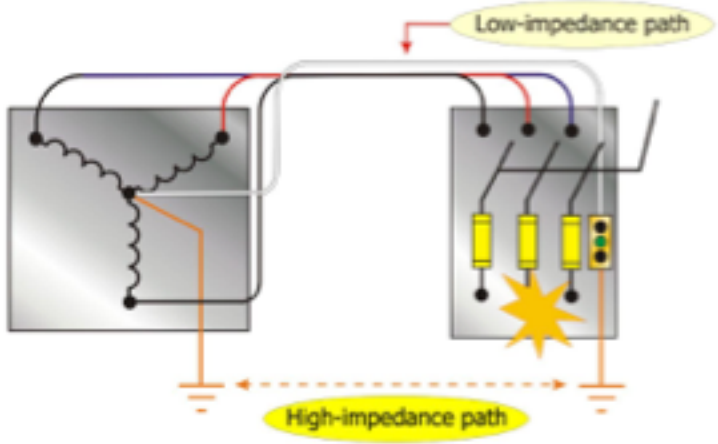
Grounded conductor not installed from source to service disconnect



Only path for return of ground-fault current from service disconnect to grounded source is a high-impedance path

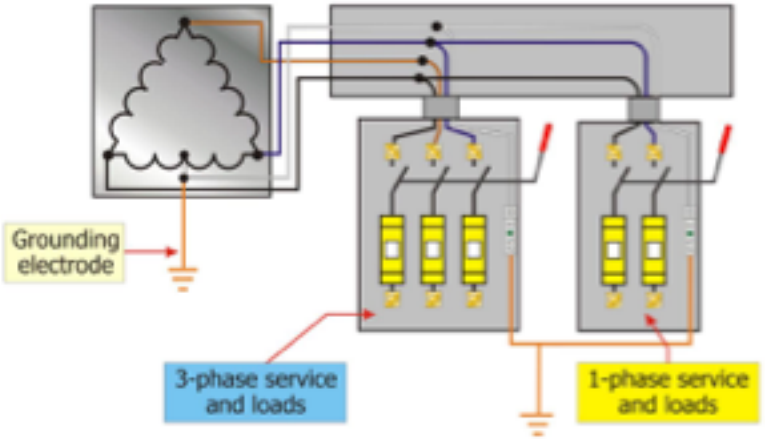
Low-Impedance Path

Grounded conductor installed from source to service disconnect



Both high- and low-impedance paths for return of ground-fault current from source to service disconnect to source

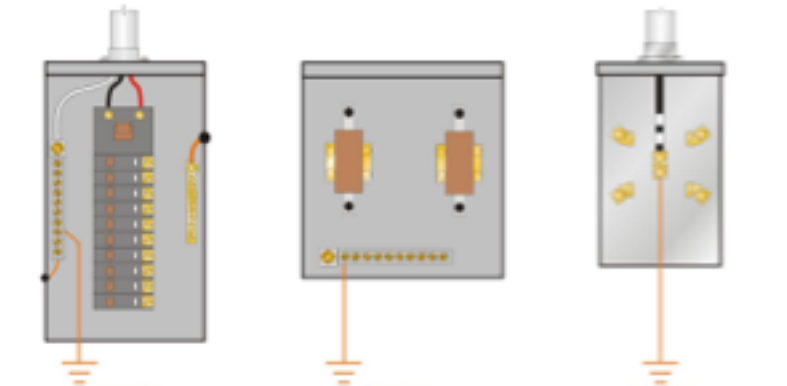
Power and Lighting Service for 3-Phase System



Grounded service conductor run to both service disconnects and bonded to each enclosure

Service Grounding Connection to be Accessible

Location of grounding electrode conductor connection to grounded service conductor must be accessible and at load end of overhead service conductors, service drop, underground service conductors, or service lateral



See 250.24(A)(1)

Minimum Size of Grounded Service Conductor

- Calculate load on grounded conductor according to 220.61
- Compare calculated size with Table 250.102(C)(1)
- Use larger of two conductor sizes determined
- Grounded conductor shall not be smaller than specified in Table 250.102(C)(1)
- Use 12½ percent rule for service-entrance conductors that exceed the kcmil values given in Table 250.102(C)(1) *(see Note 1 to table)*
- Grounded conductor based on size of ungrounded service conductors, not on overcurrent device rating

Minimum Size of Grounded Service Conductor

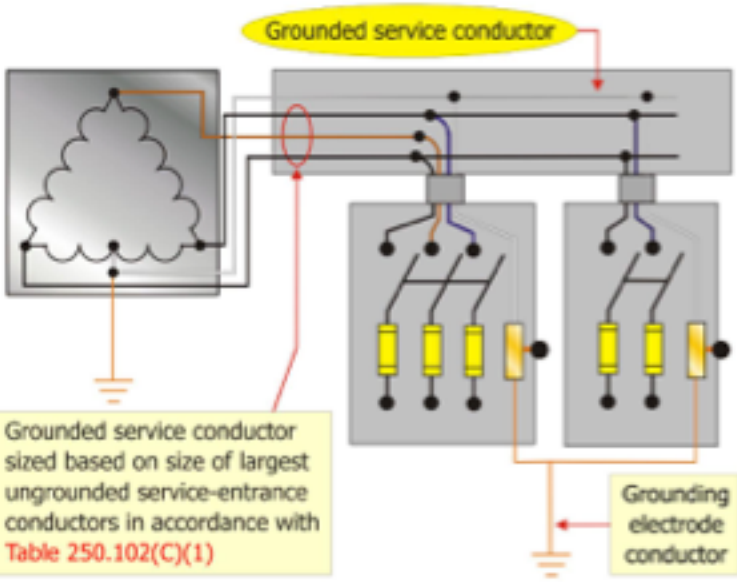


Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper* (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes 1 and 2	

Notes:
[See NEC for complete text of the (4) notes to Table 250.102(C)(1)]

*For the purposes of applying this table and its notes, the term bonding jumper refers to main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers.

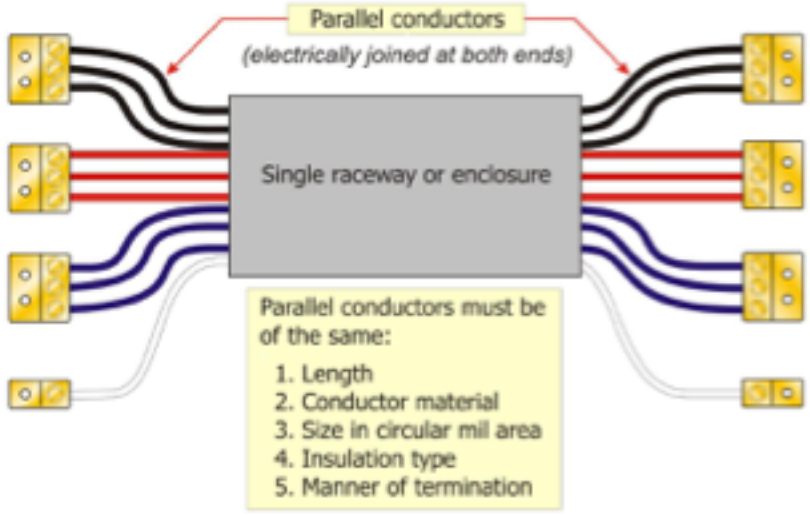
Dwelling Unit Services and Feeders

- Special rules for dwelling unit services and the main power feeder at 310.15(B)(7)(1) through (4)
- Grounded conductor is permitted to be smaller than ungrounded conductors
- Section 215.2 - feeder to be adequate for load, of minimum sizes, and not larger than the service-entrance conductors
- 220.61 - calculation of feeder neutral load; carry maximum unbalanced load
- 230.42 - sufficient to carry the load, not smaller than required by 250.24(C)(1)
- 250.24(C)(2) is required for parallel service-entrance conductors *(not smaller than 1/0)*

Sizing Parallel Grounded Conductors

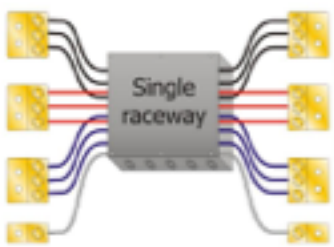
- Where the service-entrance conductors are **run in parallel**, the size of the grounded conductor shall be based on the total cm area of the parallel conductors in the same enclosure
- Where the service-entrance conductors are installed in **two or more raceways**, the size of the grounded conductor shall be based on the size of the ungrounded service-entrance conductor in the raceway but not smaller than 1/0
- See 250.24(C)(2)

310.10(H) Parallel Service Conductors



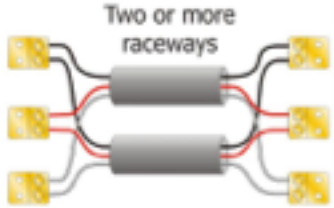
*(Parallel conductors are generally required to be 1/0 AWG and larger in size)

Parallel Service Conductors



Where all service-entrance conductors are in the same raceway, the grounded conductor is to be sized at not less than given in Table 250.102(C)(1) *[see 250.24(C)(1)]*

For ungrounded conductors larger than Table 250.102(C)(1), sizing of grounded conductors to be not less than 12½ percent of total area of largest set of ungrounded conductors per Table 250.102(C)(1), Note 1



Where installed in two or more raceways, the grounded conductor size is based on the size of the ungrounded conductors in each raceway based on Table 250.102(C)(1), but not smaller than 1/0 AWG *[see 250.24(C)(2)]*

Parallel Service-Entrance Conductors

Example Number 1:

3 - 4/0 copper conductors per phase

Chapter 9, Table 8

4/0 = 211,600 circular mils

3 X 211,600 = 634,800 cm

Refer to Table 250.102(C)(1)

Minimum size grounded service conductor is **2/0 copper** or **4/0 aluminum**

Parallel Service-Entrance Conductors

Example Number 2:

6 - 4/0 copper conductors per phase

Chapter 9, Table 8

4/0 = 211,600 circular mils

6 X 211,600 = 1,269,600 cm

Exceeds 1100 kcmils of T. 250.102(C)(1), use **12.5% rule**

1,269,600 cm x .125 = 158,700 cm

Chapter 9, Table 8, next larger size = **3/0 copper**

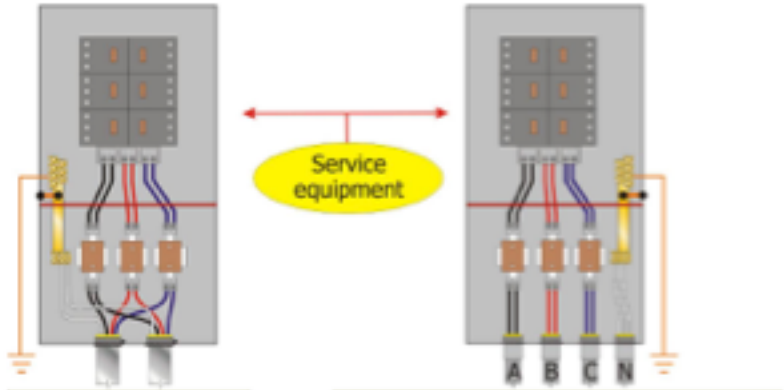
Underground Parallel Service Conductors

- All conductors of each phase permitted to be installed in the **same raceway** for **underground installations** in **nonmetallic raceways** *[300.3(B)(1) Exception]*
- Also permitted by 300.5(I) Exception No. 2
- All the ungrounded conductors of phase A are permitted to be installed in one raceway, phase B in another, phase C in the third, and the grounded service conductors in another
- Allows phase conductors to readily line up with bus terminations in bottom-fed switchboards
- Reduces the "rat's nest" in the bottom of enclosures caused by many conductors crossing each other for termination

Underground Parallel Conductors

All conductors of the same circuit *(including the grounded conductor)* are generally required to be contained within the same raceway

Per exception, Isolated phase arrangement permitted in nonmetallic raceways



Metallic raceways: 300.3(B), 310.10(H)

Isolated phase arrangement permitted in nonmetallic raceways: 300.3(B)(1) Ex., 300.5(I) Ex. No. 2, 300.20(B), 310.10(H)

Multiple Services to One Building

- Multiple services to one building permitted under one of several conditions allowed by 230.2
- Each service supplied from a grounded system must be provided with a **grounded service-entrance conductor**
- Size of ungrounded service-entrance conductor *(for each service)* determines the minimum size grounded service conductor for that service
- Each service is considered individually for sizing the grounded service conductor

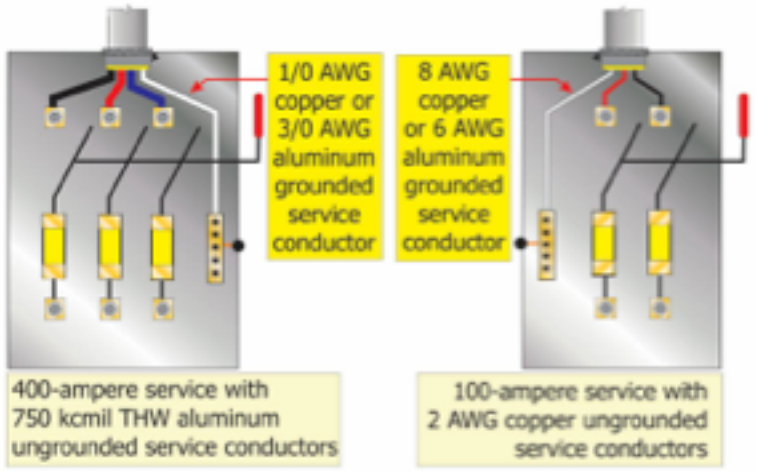
Multiple Services to One Building

- **Example:**
- Building has a 400-ampere, 480-volt 3-phase service and a 100-ampere 120/240-volt service
- Minimum size of grounded service conductor is determined as follows:
  - 400-ampere service
  - 750 kcmil THW aluminum ungrounded service conductors
  - Table 250.102(C)(1) = **1/0 AWG copper** or **3/0 AWG aluminum** grounded service conductor

Multiple Services to One Building

- **Example: *(cont.)***
- Building has a 400-ampere, 480-volt 3-phase service and a 100-ampere 120/240-volt service
- Minimum size of grounded service conductor is determined as follows:
  - 100-ampere service
  - 2 AWG copper ungrounded service conductors
  - Table 250.102(C)(1) = **8 AWG copper** or **6 AWG aluminum** grounded service conductor

Two Services to One Building from Grounded System



Minimum size of grounded service conductor to each service is based upon the size of ungrounded service conductor to each individual service

See 250.102(C)(1) and Table 250.102(C)(1)

Multiple Services to One Building

- This method determines minimum size of grounded service conductor to comply with 250.24(C)
- Larger conductor may be required to carry the maximum unbalanced load on the neutral conductor as determined by 220.61

High-Impedance Grounded Neutral Systems

- Continuous industrial process plants and other continuous operations such as data centers often need uninterrupted electrical power and systems
- Common to see these plants located near a power company substation with more than one high-voltage service supply to improve system reliability
- **High-impedance grounded neutral systems** *(rather than solidly grounded systems)* is another step that is commonly taken to improve system reliability

High-Impedance Grounded Neutral Systems (cont.)

- Advantages to high-impedance grounded neutral systems include:
  - Improved reliability
  - Ability to have ground-fault relaying that alarms rather than trips
  - Fewer problems to the system from transient overvoltages

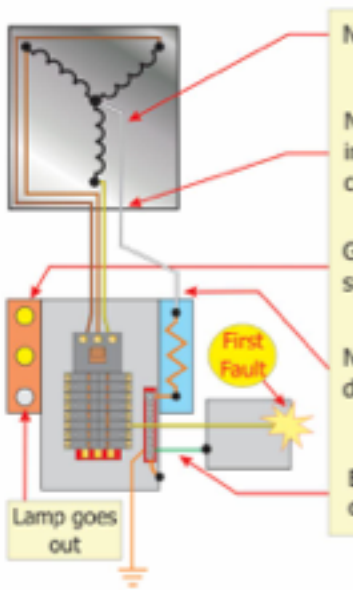
High-Impedance Grounded Neutral Systems (cont.)

- Three conditions must be met before the *Code* will permit high-resistance grounded neutral systems to be installed:
  - Qualified persons must be available to service the system
  - Ground detectors must be installed to indicate an insulation failure
  - Line to neutral loads are not served
- See 250.36

High-Impedance Grounded Neutral Systems (cont.)

- Systems in which a grounding impedance *(usually a resistor)* limits the ground-fault current to a low value by installing the resistor between the transformer supplied grounded service-entrance conductor and the grounding electrode
- Permitted for 3-phase ac systems of 480 volts to 1000 volts
- Impedance device is typically sized to a value greater than the capacitive charging current of the system *(for 480-volt systems, this is usually about 10 amperes)*
- Provides enough separation so that a fault will still be detected at minimal damage levels while normal charging current would not be detected causing false alarms

High-Impedance Grounded Neutral Systems



Neutral must be a fully insulated

Not smaller than current rating of impedance device, minimum 8 AWG copper or 6 AWG aluminum

Ground detectors installed on the system

Neutral connects to the impedance device

Equipment grounding conductor(s) connected below impedance device

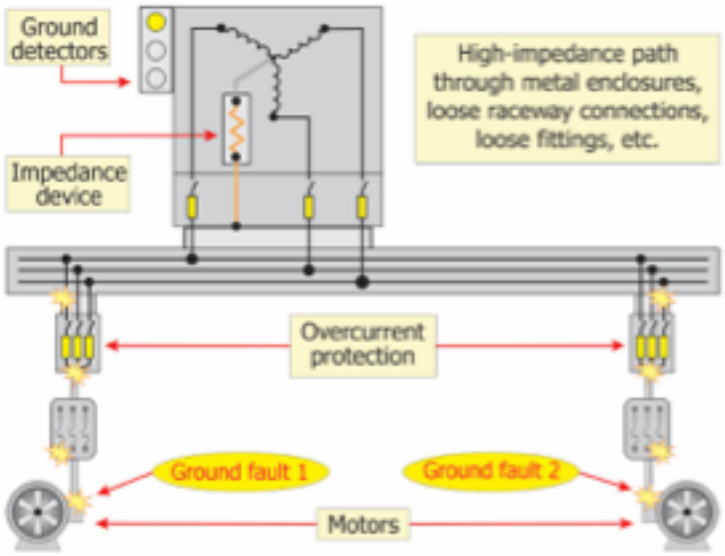
See 250.36(A) through (G)

Equipment for High-Impedance Grounded Neutral Systems

Resistor for high-impedance grounded neutral system with single-phase grounding transformer *(provides low current grounding at voltages 2.4 kV and higher)*

High resistance grounded system cabinets complete with tapped resistor and controls

Second Ground Fault on High-Impedance Grounded Neutral System



Grounding of Ungrounded Systems

- Ungrounded systems that experience a ground fault are subject to relatively severe transient over-voltages that can reach several times normal voltage to ground
- Such abnormal voltages become potential hazards and often cause insulation failure and equipment breakdowns in other parts of the system
- Grounded systems *(with one conductor purposely grounded)* greatly reduces the value of such transient over-voltages as they develop

Grounding of Ungrounded Systems *(cont.)*

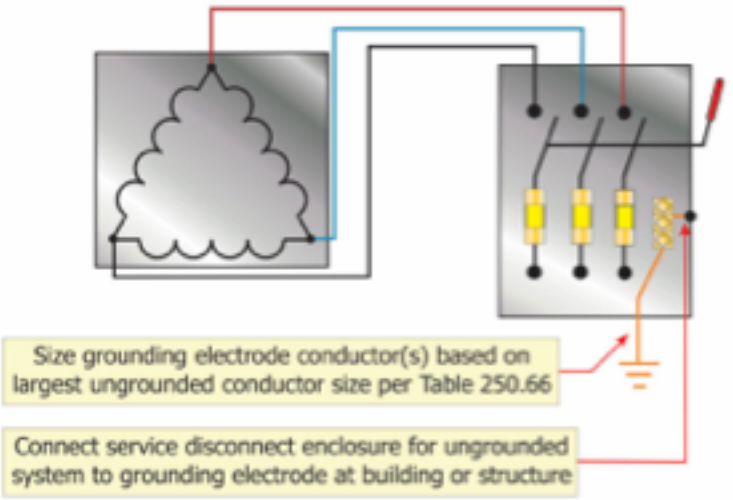
- Ungrounded system must have its conductor and equipment enclosures connected to a grounding electrode system at the building or structure served
- This keeps such enclosures as near to ground potential as possible and reduces shock hazards to a minimum
- Service equipment enclosures are grounded by connecting them to a grounding electrode system

Grounding of Ungrounded Systems *(cont.)*

- Enclosures, raceways, etc. of an ungrounded system are required to be grounded
- Grounding electrode system and equipment grounding conductors are required
- **No system grounded conductor present**
- Grounding electrode conductor sizing based on 250.66 using the largest ungrounded phase conductor(s)
- Equipment grounding conductors in ungrounded systems are sized based on the rating of the overcurrent device using Table 250.122
- See 250.24(E)

Grounding Requirements for Ungrounded Systems

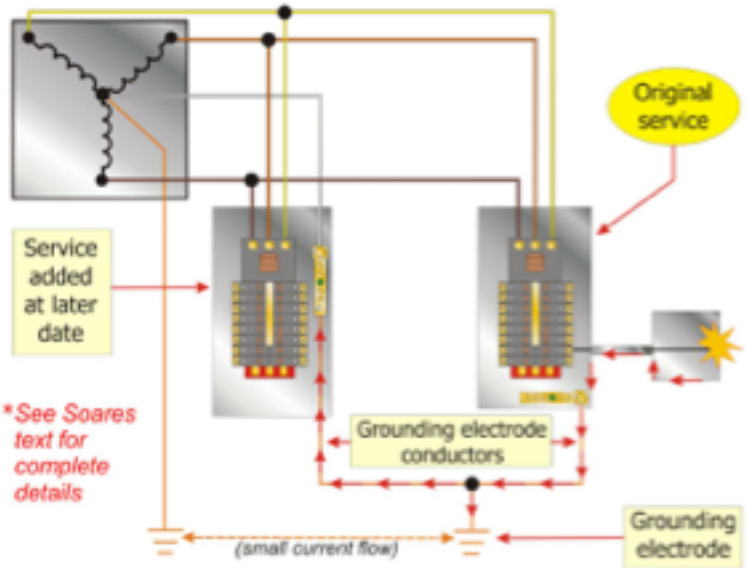
Enclosures, raceways, etc. of an ungrounded system are required to be grounded



Hazard of Services Without a Grounded Conductor Supplied from a Grounded System

- The illustration on the next slide illustrates the hazard of operating a service from a grounded system without installing a grounded service conductor
- Original ungrounded service *(on right)* in the illustration existed before the newer service *(on left)* was installed
- First and original service was supplied by an ungrounded utility system with the service and feeder shown supplying equipment protected by large overcurrent devices
- Sometime later, the service on the left, which included a grounded service conductor, was installed
- ***See Soares textbook (page 82) for complete details***

Hazard of Ungrounded Service from Grounded System Without a Grounded Conductor



Chapter Five:
Main Bonding Jumpers and Bonding at Services

- Definitions of bonding and bonding jumpers
- Functions of the main and supply-side bonding jumper
- Sizing of the main and supply-side bonding jumpers
- Methods for bonding at service equipment
- Use of grounded conductor (neutral) for bonding on line side of service
- Requirements for grounding and bonding of remote metering

Main Bonding Jumpers and Bonding at Services

- Main bonding jumper is one of the most critical elements in the safety grounding and bonding system
- Main bonding jumper serves as the link between:
  - Grounded service conductor
  - Equipment grounding conductor(s)
  - Grounding electrode conductor

Main Bonding Jumpers and Bonding at Services *(cont.)*

- Primary purpose of the main bonding jumper is to **carry the ground-fault current** from the service enclosure and from the equipment grounding conductor system that is returning to the source during ground-fault conditions
- Ensures equipment grounding bus is at the **same potential as the earth** where the grounding electrode conductor is connected directly to the grounded service conductor *(neutral)* bus
- Main bonding jumper **completes the earth connection** to the grounded (neutral) conductor where the grounding electrode conductor is connected to the equipment grounding bus as permitted in 250.24(A)(4)

Definitions

- ***Bonded (Bonding):*** "Connected to establish electrical continuity and conductivity"
- ***Bonding Jumper, Main:*** "The connection between the grounded circuit conductor and the equipment grounding conductor at the service"
- ***Bonding Jumper, Supply-Side:*** "A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected" [250.2]

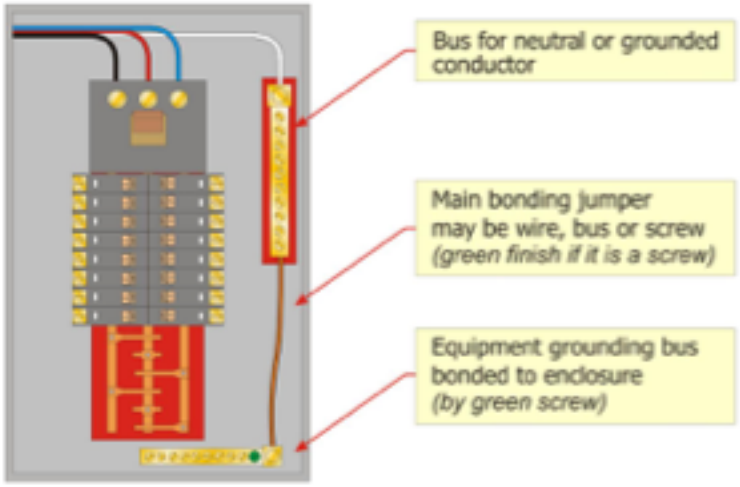
Main Bonding Jumper in Listed Equipment

- Can be used without calculation of size
- Sized in accordance with sizing requirements of the applicable product safety standard
- Example:
  - Dead-front switchboards, UL-891
  - Motor Control Centers, UL-845
  - Panelboards, UL-67
  - Power Outlets, UL-231
  - Furnished by the manufacturer

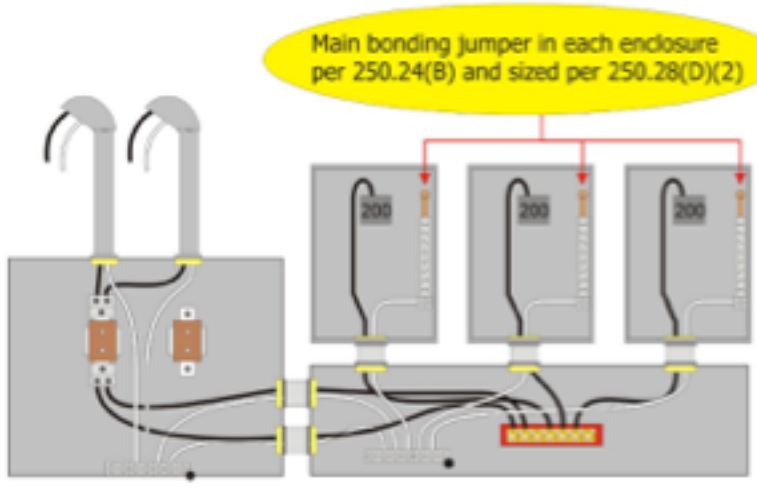
Main Bonding Jumper

- For a grounded system, 250.24(B) requires an unspliced main bonding jumper to be used to connect:
  - **Equipment grounding conductor(s)** and the **service disconnect enclosure** to the **grounded conductor** of the electrical system
- Connection must be made within the enclosure for **each service disconnect** *(see 250.28)*

250.28 Main Bonding Jumper



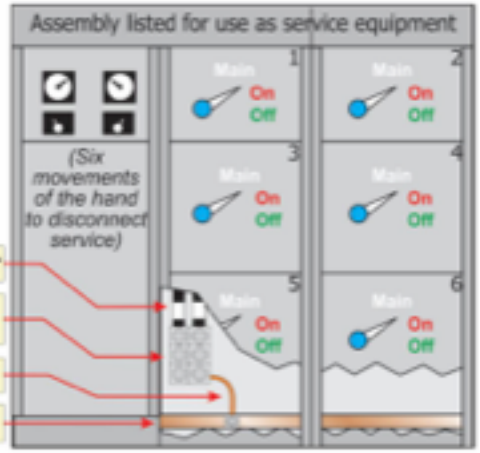
Main Bonding Jumper - Multiple Enclosures

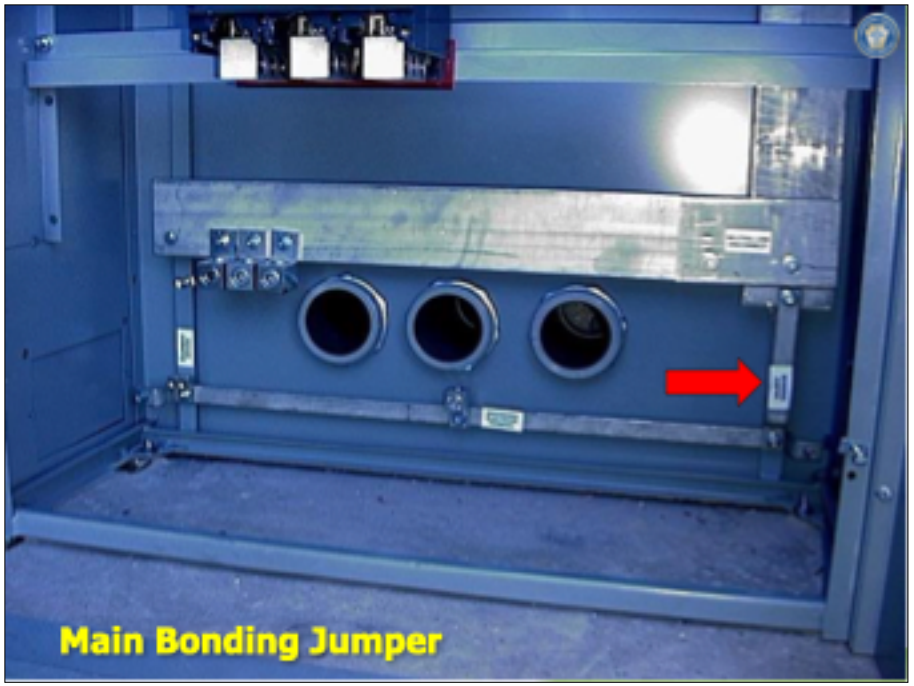


Main Bonding Jumper in Multiple Disconnect Service Equipment

For grounded systems, an unspliced main bonding jumper is required to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within the enclosure for each service disconnect

Where more than one service disconnecting means is located in an assembly listed for use as service equipment, an unspliced main bonding jumper is permitted to bond the grounded conductor(s) to the assembly enclosure per 250.24(B) Ex. No. 1



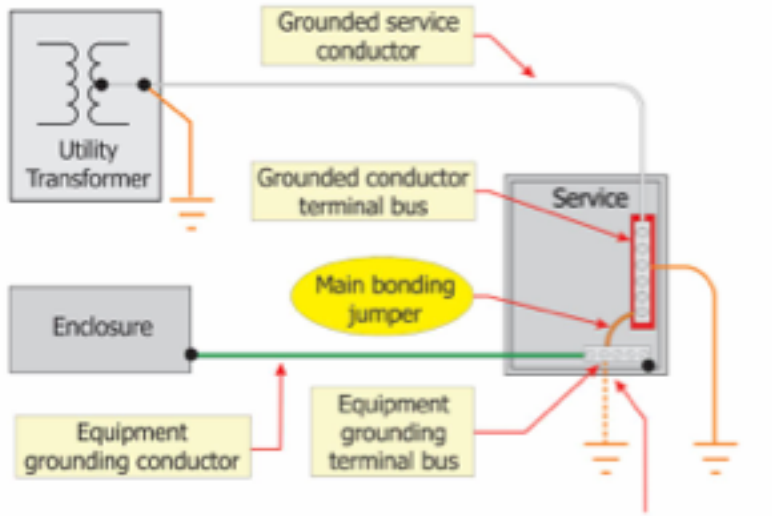

Main Bonding Jumper


NEUTRAL LINK
DISCONNECT

Functions of Main Bonding Jumper

- The main bonding jumper performs **three major functions**:
  - Connects grounded service conductor to the equipment grounding bus or conductor and the service enclosure
  - Provides **low-impedance path** for return of ground-fault currents to the grounded service conductor by completing the ground-fault return circuit from the equipment grounding conductors and enclosure to the source via the service grounded (neutral) conductor
  - Connects the grounded service conductor to the grounding electrode conductor where the grounding electrode conductor is terminated on the equipment grounding bus or bar

Major Functions of Main Bonding Jumper

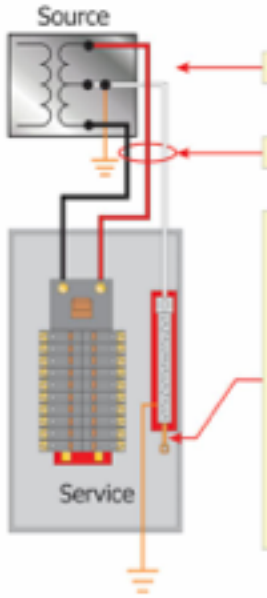


Grounding electrode conductor connection permitted here per 250.24(A)(4)

Sizing of Main Bonding Jumper

- Main bonding jumper must carry the full ground-fault current of the system back to the grounded service conductor *(which may be a neutral)*
- Size must relate to the rating of the service conductors which supply the service
- Minimum size of the main bonding jumper is determined from the requirements of 250.28(D)

Main Bonding Jumper at Single Disconnect



Grounded electrical system

Service-entrance conductors

Size of main bonding jumper in listed service equipment in accordance with the applicable standard *(done by manufacturer)*

Size of main bonding jumper *(if conductor)* based on size of largest ungrounded service-entrance conductors

Size per Table 250.102(C)(1) and table notes

If larger than table values, 12½ percent of largest service-entrance conductor area *[see Note 1 to Table 250.102(C)(1)]*

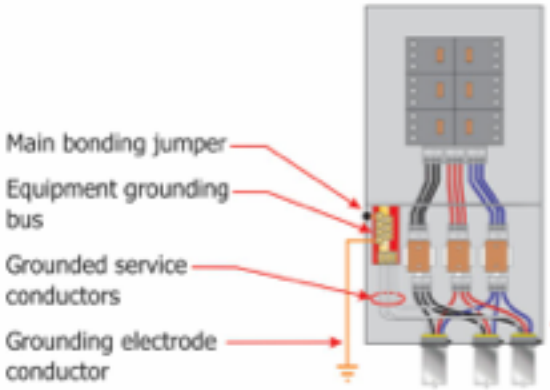
Sizing Main Bonding Jumper *(Conductor)*

- **Example 1:**
  - 250 kcmil aluminum service-entrance conductors
  - Table 250.102(C)(1)
  - Minimum **4 AWG copper** or **2 AWG aluminum** or copper-clad aluminum main bonding jumper required

Sizing Main Bonding Jumper *(Conductor)*

- **Example 2:** (3) 500-kcmil copper conductors are installed in parallel as service-entrance conductors
  - Add circular mil area together and if larger than 1100 kcmil copper or 1750 kcmil aluminum, use **12½ % rule**
  - 3 x 500 kcmil = 1500 kcmil
  - 1500 x .125 = 187,500 circular mils
  - Refer to *NEC* Chapter 9, Table 8
  - Next conductor that would exceed 187,500 circular mils is a **4/0 AWG conductor** *(211,600 circular mils)*

Sizing Main Bonding Jumper *(Conductor)* for Parallel Service Conductors



Step 1- (3) 250 kcmil aluminum conductors per set *[3 x 250 = 750 kcmil]*

Step 2- Refer to Table 250.102(C)(1)

Step 3- Minimum size MBJ (conductor) for 750 kcmil aluminum: 1/0 AWG copper or 3/0 AWG aluminum

Supply-Side Bonding Jumper

- Review of the definition:
  - ***Bonding Jumper, Supply-Side:*** "A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected" *[250.2]*

Functions of Supply-Side Bonding Jumper

- Supply-side bonding jumper provides **electrical continuity** between the supply source *(such as the utility transformer enclosure)* and the various enclosures of the service equipment
- Connects bonding bushings *(where used)* to service grounded *(neutral)* conductor in service equipment enclosure(s)
- Carries ground-fault current from ground faults that occur on the supply side of the main overcurrent protection
- Provides a low impedance path for the ground-fault current to return to the source

Supply-Side Bonding Jumper

- Supply-side bonding jumper can be non-flexible metal raceway or a wire type
- Service grounded conductor can sometimes also serve as the supply-side bonding jumper

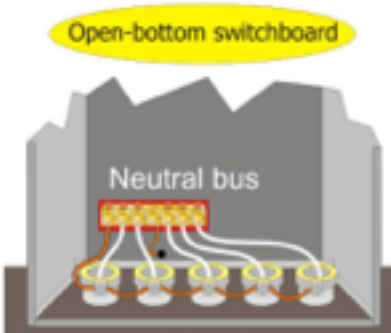
Sizing Supply-Side Bonding Jumpers

- Line side of service and main bonding jumper
- Size per Table 250.102(C)(1)
- Based on size of ungrounded service-entrance conductor(s)
- Use rules in 250.102(C)
  - Parallel conductors in the *same* raceway or enclosure *[see 250.102(C)(1)]*
  - Parallel conductors in *separate* raceways or enclosures *[see 250.102(C)(2)]*

Size of Supply-Side Bonding Jumper on Line Side of Service

Where installed in series, a supply-side bonding jumper is sized for the total circular mil area of ungrounded service-entrance conductors installed in parallel

Single supply-side bonding jumper connects all conduits together and then is bonded to the service grounded *(neutral)* bus

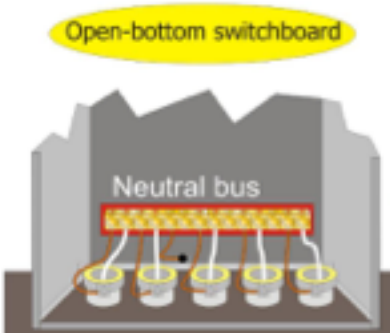


Note: Metal enclosure and raceways must be connected to the grounded conductor/neutral bus per 250.80

Size of Supply-Side Bonding Jumper on Line Side of Service

Where installed individually, supply-side bonding jumpers are sized based on the total circular mil area of ungrounded service-entrance conductors installed in each raceway

Individual supply-side bonding jumpers bond all conduits to the service grounded *(neutral)* bus



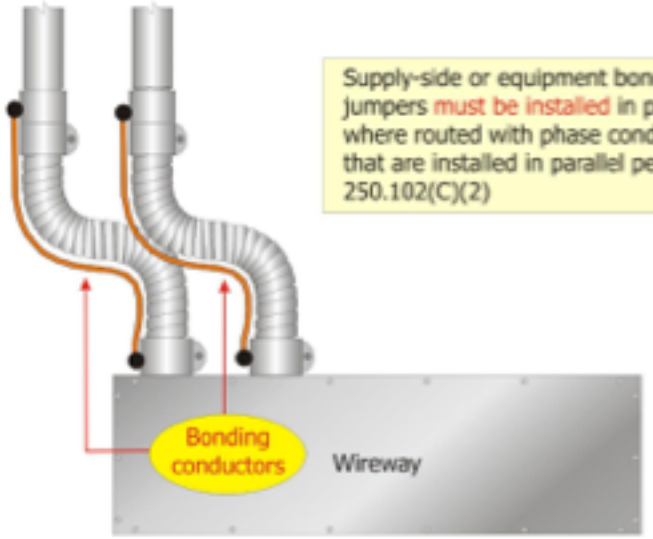
Note: Metal enclosure and raceways must be connected to the grounded conductor/neutral bus per 250.80

Parallel Supply-Side Bonding Jumpers

- Paralleled service-entrance conductors installed in two or more raceways or cables along with supply-side bonding jumpers require the supply-side bonding jumpers to be run in parallel as well *[see 250.102(C)(2)]*
- Size of the bonding jumper for each raceway is based upon size of the service-entrance conductor in the raceway *[Table 250.102(C)(1) and 250.102(C)(2)]*
- Must make bonding jumper connections on both sides of the raceway with equipment or fittings that are suitable for that use

250.102(C)(2) Parallel Bonding Conductors

Supply-side or equipment bonding jumpers must be installed in parallel where routed with phase conductors that are installed in parallel per 250.102(C)(2)



Bonding Service Equipment Enclosures

- Special rules are provided for bonding enclosures on the line side of the service disconnecting means
- All metallic enclosures that contain service conductors must be bonded together
- This equipment does not have overcurrent protection on the line side *(like feeders and branch circuits)*
- See 250.92(A)

Bonding Service Equipment Enclosures *(cont.)*

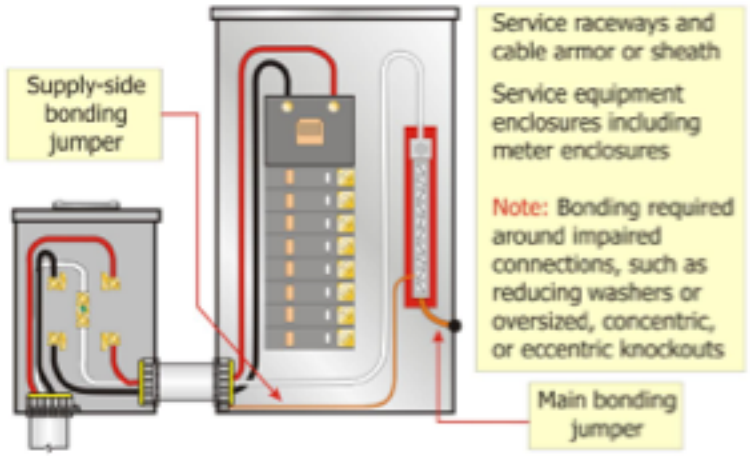
- Bonding at service equipment:
  - Ensures that none of the equipment enclosures can become **electrically isolated** and become a shock hazard should a line-to-ground fault occur in that enclosure
  - Provides a **low-impedance path** for fault current so the fuse or circuit breaker on the supply side of the electric utility transformer will open or operate
- See 250.92(A)(1) and (A)(2)

Bonding Service Equipment Enclosures *(cont.)*

- The normally non-current-carrying metal parts of service equipment required to be effectively bonded together include:
  - Service raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors *(except as permitted in 250.80)*
  - All enclosures containing service conductors, including meter fittings, boxes or the like, interposed in the service raceway or armor
- See 250.92(A)

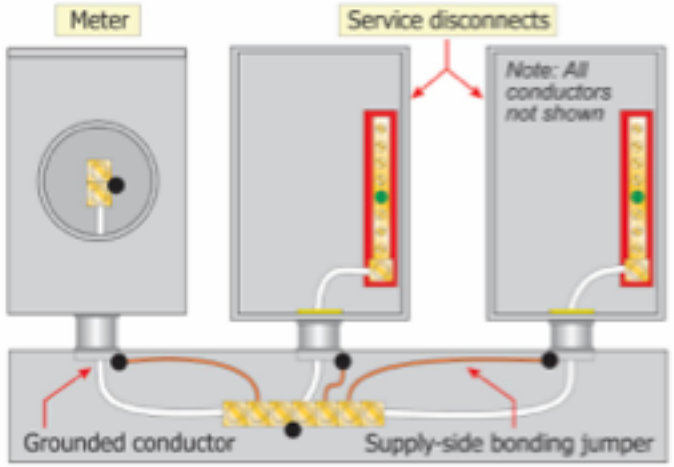
250.92(A) Bonding Service Equipment Enclosures

The normally non-current-carrying metal parts of service equipment required to be bonded together include:



Bond together in a method specified by 250.92(B) and size bonding jumpers per sizes in Table 250.102(C)(1)

Use of Grounded *(Neutral)* Conductor for Bonding *(Line Side of Service)*



Grounded conductor permitted to be used for grounding on the supply side of the service disconnect(s) in accordance with 250.142(A)(1)

Methods of Bonding at Service Equipment Enclosures

- Various methods for bonding at the service are addressed by the *Code*
- Bonding requirements are more restrictive at services than downstream from the service disconnect
- Service equipment and enclosures can be subject to heavy fault currents in the event of a line-to-ground fault
- Overcurrent protection is controlled by the serving utility
- See 250.92(B)

Methods of Bonding at Service Equipment Enclosures *(cont.)*

- Service conductors only have **short-circuit protection** provided by the overcurrent device on the line side of the utility transformer
- Only **overload protection** is provided at the load end of the service conductors by the service main overcurrent device
- One reason the *Code* limits the length of service conductors inside a building by requiring the service disconnecting means to be "nearest the point of entrance" of the service conductors *[see 230.70]*
- Various methods for bonding at the service are illustrated on the next few slides

250.92(B) Bonding Fittings

Bonding Locknut — Used where no concentric or eccentric knockouts remain
(Standard locknut permitted on opposite side)

Bonding Wedge — Use with bonding jumper around concentric or eccentric knockouts; with or without bonding jumper where no concentric or eccentric knockouts
(Standard locknut permitted on opposite side)

Bonding Locknut Suitable for Service Bonding

Courtesy of Thomas and Betts

Bonding Wedge Suitable for Service Bonding

Courtesy of Thomas and Betts

250.92(B) Methods of Bonding Service Equipment

Threadless couplings and connectors made up tight for rigid metal conduit, intermediate metal conduit, and electrical metallic tubing

Conduit hub furnished in many trade conduit sizes as accessory by equipment manufacturer
(Install according to manufacturer's instructions)

Threaded couplings or bosses on enclosures made up wrenchtight


DANGER


Courtesy of Thomas and Betts

Methods of Bonding at Service *[250.92(B)]*

- Listed lugs, pressure connectors, other listed means *(250.8)*
- Threaded couplings and connectors or threaded hubs on enclosures where made up wrenchtight
- Threadless couplings and connectors if made up tight for metal raceways or metal-clad cables
- Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers
- Standard locknuts are not permitted for the bonding required by this section
- Bonding jumpers are required to be used around impaired concentric or eccentric knockouts
- Connections cannot depend on solder *[250.148(E)]*

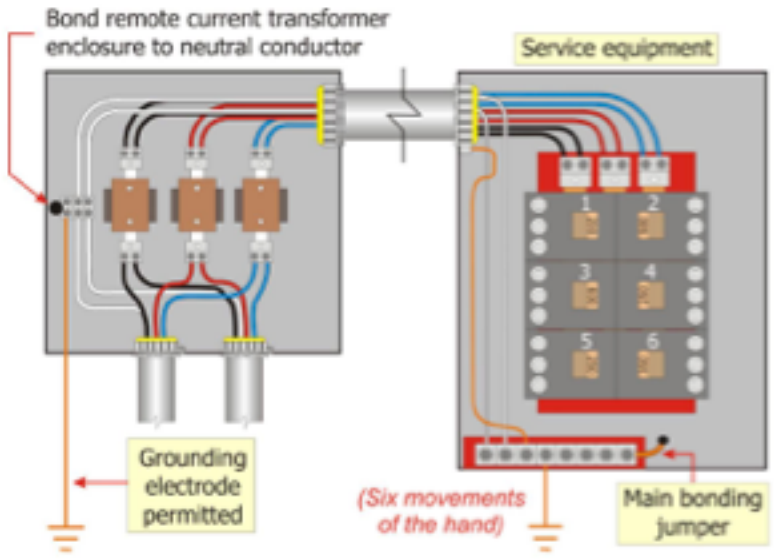
Grounding and Bonding of Remote Metering

- All metallic equipment containing service conductors required to be bonded together and to the **grounded service conductor** *[see 250.92(A)]*
- This includes remote *(from the service equipment)* meter cabinets and meter socket enclosures, current transformer cabinets, raceways, and auxiliary gutters
- Grounding and bonding of equipment to the **grounded service conductor** at locations on the line side of and remote from the service disconnecting means increases safety

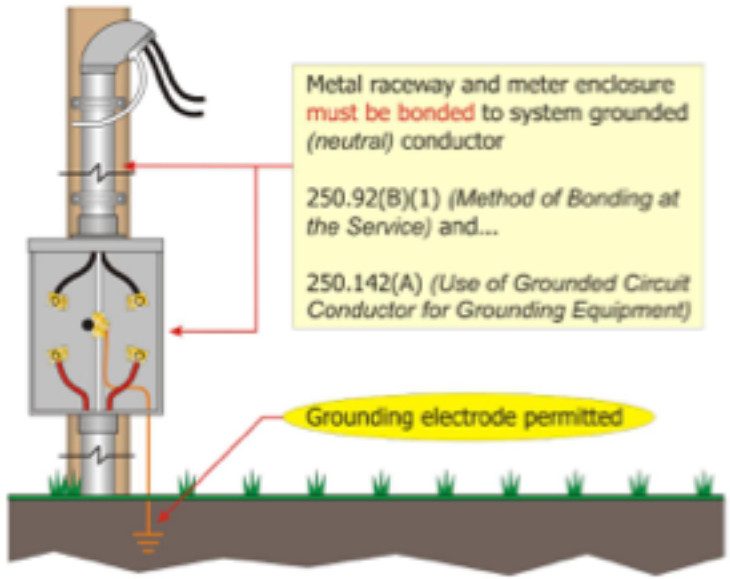
Grounding and Bonding of Remote Metering *(cont.)*

- Remote equipment should never be grounded only to a grounding electrode *(such as a ground rod)*
- If a ground fault occurred on the line-side of remote equipment *(and not bonded as required)*, only means for clearing ground fault would be through the grounding electrodes and earth *(high impedance path)*
- No overcurrent device will open or operate, leaving the equipment enclosure(s) at a dangerous voltage-to-ground potential
- Any person or animal that contacts the enclosure can be shocked or electrocuted

Grounding and Bonding of Remote Metering



Bonding Remote Meter Loop

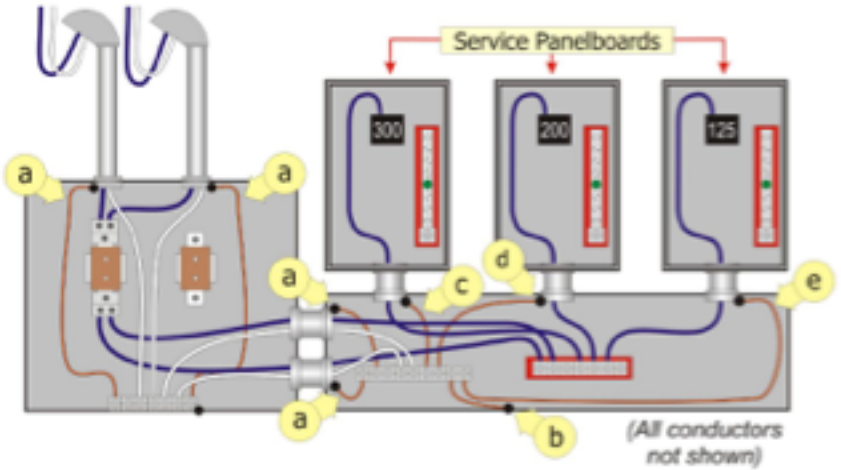


Bonding of Multiple Service Disconnecting Means

- Installation of multiple services permitted by 230.2(A) through (D)
- Installations of services that have multiple disconnecting means can take several forms
- Basic rule for sizing the supply-side bonding jumper for bonding these various configurations is found at 250.102(C)
- Supply-side bonding jumpers on the line side of each service and the main bonding jumper sized from Table 250.102(C)(1)
- Size of supply-side bonding jumper for each raceway based on the size of service-entrance conductors in that raceway

Bonding of Multiple Service Disconnecting Means

Size supply-side bonding jumpers in accordance with 250.102(C)



Note: See next slide for legend

Sizing Supply-Side Bonding Jumpers

- The appropriate size of supply-side bonding jumpers for the installation in Figure 5-16 with the assumed size of conductors is as follows: *(all sizes copper)*
  - **(a)** 500 kcmil in service mast and nipple has a supply-side bonding jumper of 1/0 AWG
  - **(b)** 1000 kcmil in wireway has a supply-side bonding jumper of 2/0 AWG
  - **(c)** 300 kcmil to 300-ampere service has a supply-side bonding jumper of 2 AWG
  - **(d)** 3/0 AWG to 200-ampere service has a supply-side bonding jumper of 4 AWG
  - **(e)** 2 AWG to 125-ampere service has a supply-side bonding jumper of 8 AWG

Chapter Six:
The Grounding Electrode System

- Definitions and general requirements for grounding electrodes
- Grounding electrode system to be used
- Sizing interconnecting bonding jumpers for the grounding electrode system
- Description and installation of grounding electrodes
- Common grounding electrode
- Objectionable current flow and resistance of grounding electrodes

The Grounding Electrode System

- Grounding electrodes provide essential function of connecting the electrical system and electrical equipment to the earth
- The earth is considered to be at zero potential
- Grounding electrode(s) serves and is used to:
  - Ground the electrical system to earth
  - Connect non-current-carrying metallic portions of electrical equipment to the earth
- Primary purpose of the grounding electrode(s) is to maintain the electrical equipment at the earth potential present where the grounding electrode(s) is located

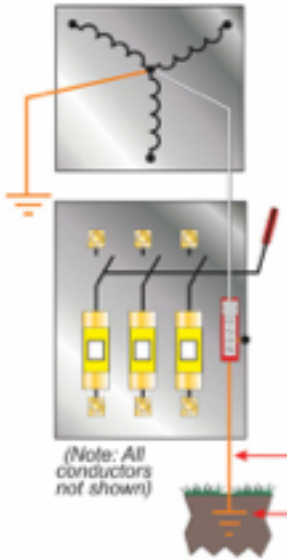
The Grounding Electrode System *(cont.)*

- Grounding electrode(s) serves the function of dissipating overvoltages into the earth
- Overvoltages can be caused by high-voltage conductors being accidentally connected to the lower-voltage system such as by a failure in a transformer or by an overhead conductor dropping on the lower-voltage conductor
- Overvoltages can also be caused from lightning

Definition

- ***Grounding Electrode:*** A conducting object through which a direct connection to earth is established.
- See Article 100
- The details and descriptions of the various grounding electrodes acceptable for grounding are contained in 250.52(A)
- The definition of ***grounding electrode*** is intended to work cooperatively with the list of electrodes identified in 250.52(A)

Functions of Grounding Electrode

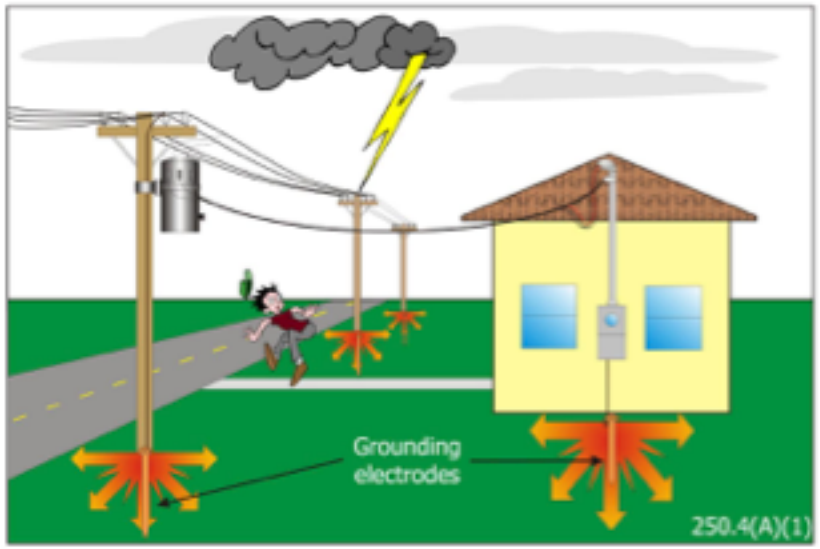


Grounding Electrode - A conducting object through which a direct connection to earth is established.

1. Connects the electrical system to earth
2. Connects electrical equipment to earth
3. Attempts to maintain equipment at the earth voltage potential

Little effect in clearing ground faults *(not its function)*

Dissipation of Over-Voltages

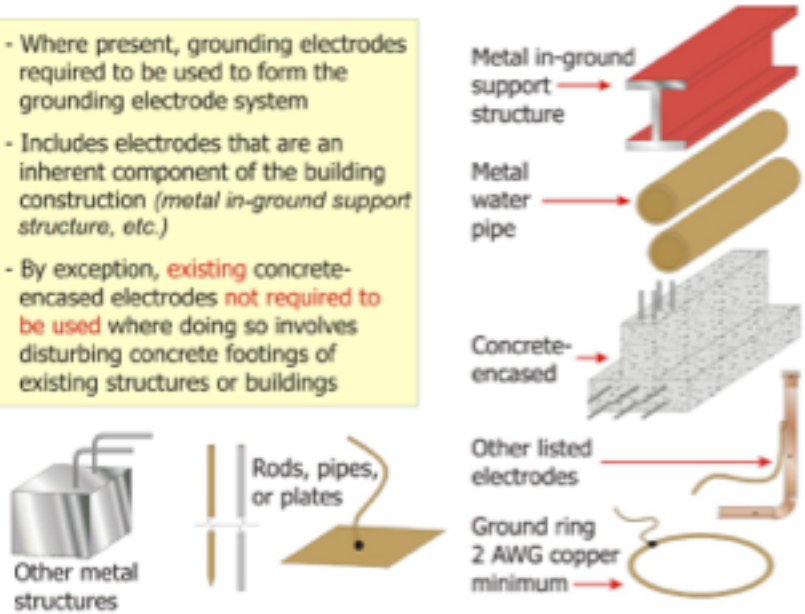


Grounding Electrode System

- All grounding electrodes **that are present** at each building or structure served are required to be bonded together to form the grounding electrode system *(see 250.50)*
- Where **metallic water piping** [250.52(A)(1)], **metallic in-ground support structure** [250.52(A)(2)], or a **concrete-encased electrode** [250.52(A)(3)] is part of the construction of the building or structure it is required to be used as a grounding electrode for the electrical system
- None of these three items are required to be installed, only used where they are installed as part of the construction of the building or structure
- Exception to 250.50 has provisions for existing buildings or structures

250.50 Grounding Electrode System

- Where present, grounding electrodes required to be used to form the grounding electrode system
- Includes electrodes that are an inherent component of the building construction *(metal in-ground support structure, etc.)*
- By exception, existing concrete-encased electrodes not required to be used where doing so involves disturbing concrete footings of existing structures or buildings



Grounding Electrodes for Grounding

- Section 250.52(A) includes the details and descriptions of grounding electrodes that are **required to be used** for the grounding electrical systems ***(when present)***
- Section 250.52(B) includes items that are **not permitted** to be used as grounding electrodes for electrical systems and equipment
- Installation provisions for the electrodes described in 250.52(A) are provided in 250.53 titled "Grounding Electrode System Installation"

Grounding Electrodes for Grounding

- Section 250.52(A) includes the details and descriptions of grounding electrodes that are **required to be used** for the grounding electrical systems *(where present)*:

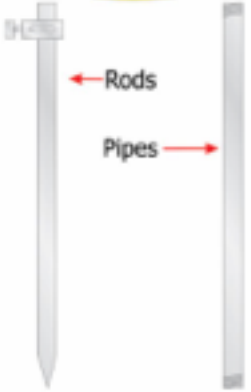
(A)(1) Metal underground water pipe
(A)(2) Metal in-ground support structure
(A)(3) Concrete-encased electrode
(A)(4) Ground ring
(A)(5) Rod and pipe electrode
(A)(6) Other listed electrodes
(A)(7) Plate electrodes
(A)(8) Other local metal underground systems or structures

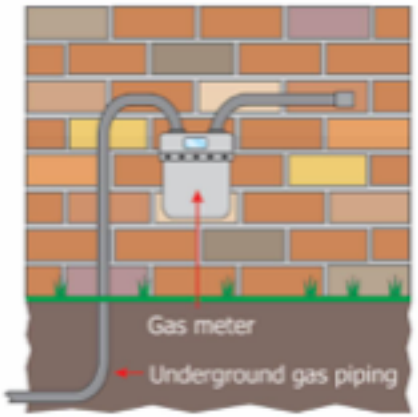
The Grounding Electrode System *(cont.)*

- Section 250.52(B) lists (3) items **NOT permitted** to be used as part of the grounding electrode system:
  - (1) Metal underground gas piping systems
  - (2) An aluminum electrode *(such as an aluminum ground rod)*
  - (3) Structural reinforcing steel for a permanently installed swimming pool

250.52(B) Not Permitted as Grounding Electrodes

Aluminum electrodes are not permitted as a grounding electrode

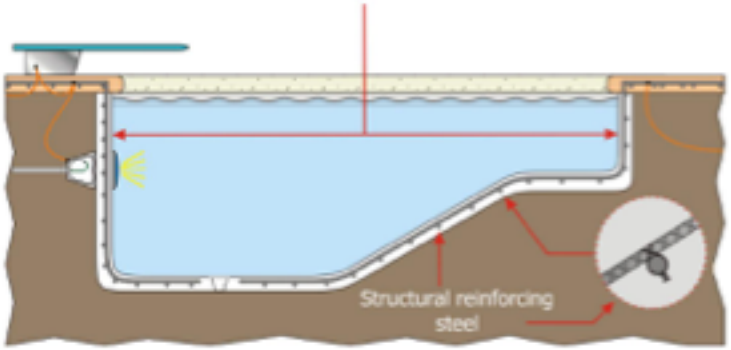




Underground gas piping is not permitted as a grounding electrode

250.52(B) Not Permitted as Grounding Electrodes

Structural reinforcing steel *(rebar forming shell)* of an in-ground swimming pool not permitted as a grounding electrode



Not permitted as grounding electrodes:
- aluminum electrodes
- underground gas piping
- structural reinforcing steel of in-ground swimming pools

Metal Underground Water Piping Systems

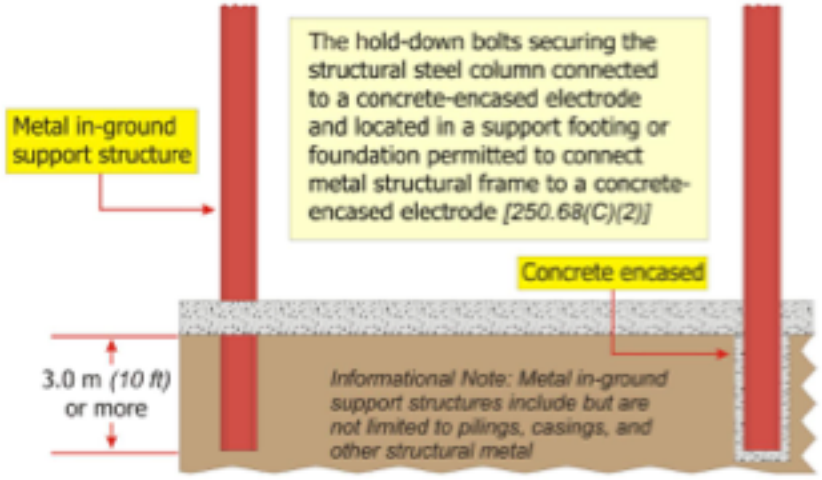
- Section 250.52(A)(1) requires **metal underground water piping systems** to be used for the grounding electrical systems *(where present)*
- Must be in direct contact with the earth for 3.0 m **(10 ft) or more** and electrically continuous
- Includes any metal well casing bonded to the pipe
- Can be made electrically continuous by bonding around insulating joints or insulating pipe
- Must not be coated or otherwise insulated from direct contact with the earth

Metal In-Ground Support Structure(s)

- Section 250.52(A)(2) requires a **metal in-ground support structure** to be used for the grounding electrical systems *(where present and qualifies)*
- Must be in direct contact with the earth vertically for **3.0 m (10 ft) or more** *(with or without concrete encasement)*
- If multiple metal in-ground support structures are present, **permitted to bond only one** into the grounding electrode system
- Could include *(but are not limited to)* pilings, casing, and other structural metal

250.52(A)(2) Metal In-Ground Support Structures

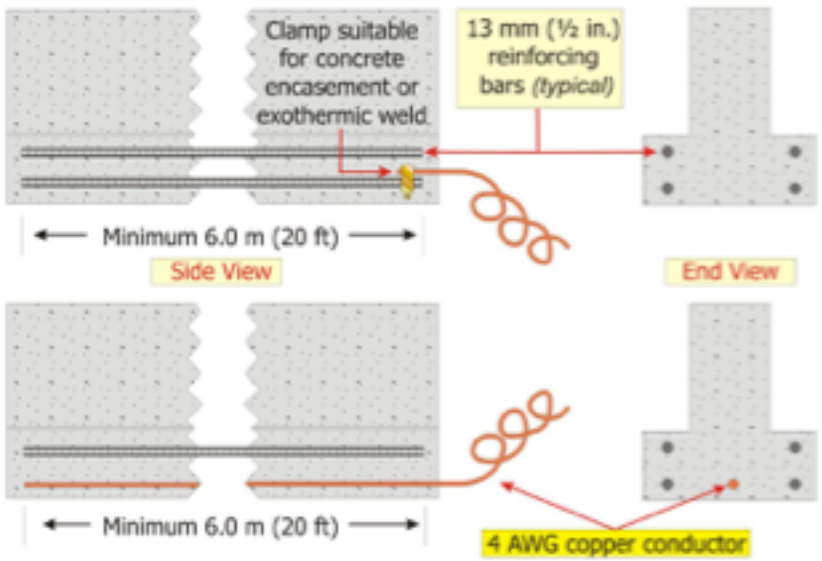
One or more structural metal in-ground support structure(s) in direct contact with the earth vertically for 3.0 m (10 ft) or more *(with or without concrete encasement)* qualifies as a grounding electrode *(if multiple are present, only one required to be used)*



Concrete-Encased Electrode

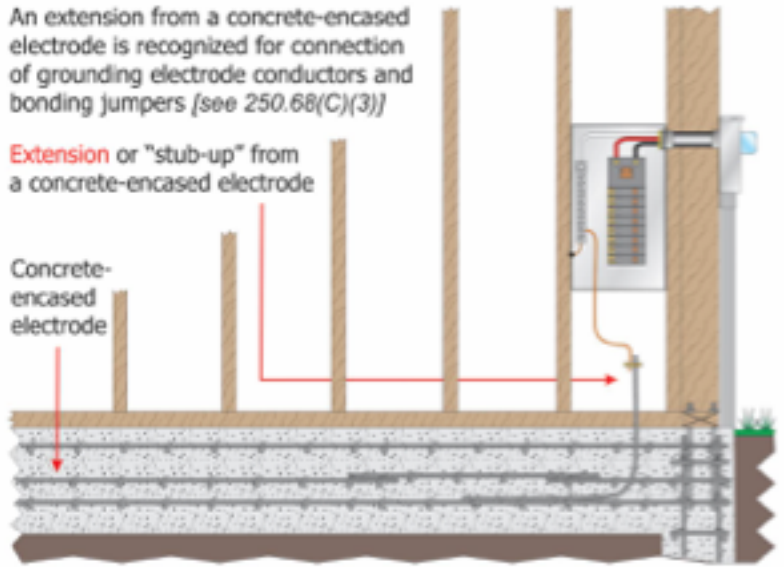
- Section 250.52(A)(3) requires concrete-encased electrodes to consist of:
  - At least **6.0 m (20 ft)** of bare copper conductor not smaller than **4 AWG** or one or more bare or electrically conductive coated steel reinforcing bars or rods of not less than **13 mm (½ in.) in diameter**
  - Installed in **one continuous 6.0 m (20 ft) length**, or multiple pieces connected together by the usual steel tie wires, exothermic welding, welding, etc. to create a 6.0 m (20 ft) or greater length
  - Metallic components encased by at least **50 mm (2 in.) of concrete**
  - Located **horizontally** within portions of a concrete foundation or footing in direct contact with the earth or within **vertical** structural components in direct contact with the earth

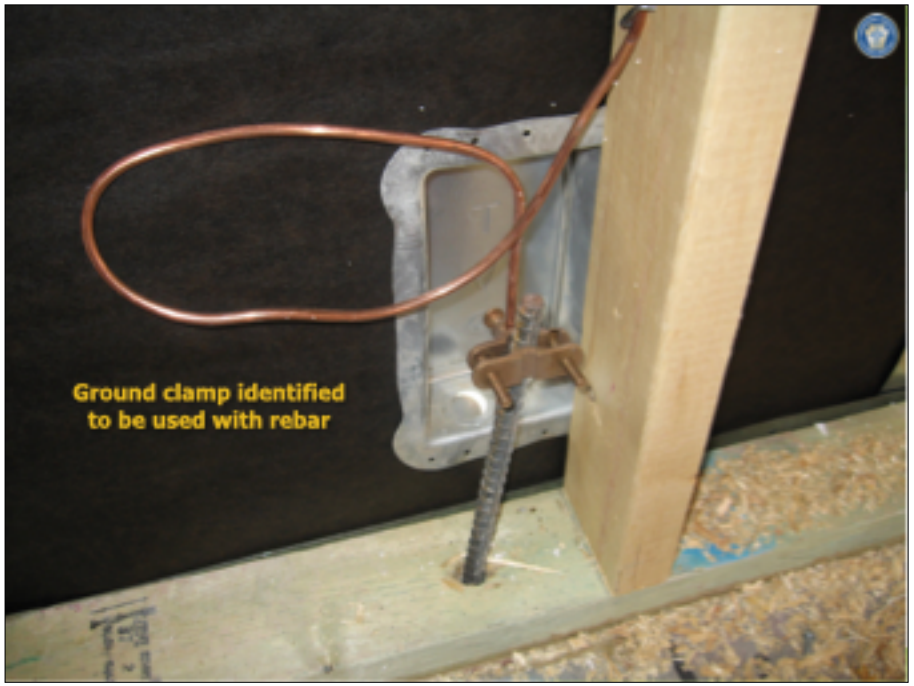
250.52(A)(3) Concrete-Encased Electrode



Concrete-Encased Electrode Extension

An extension from a concrete-encased electrode is recognized for connection of grounding electrode conductors and bonding jumpers *[see 250.68(C)(3)]*

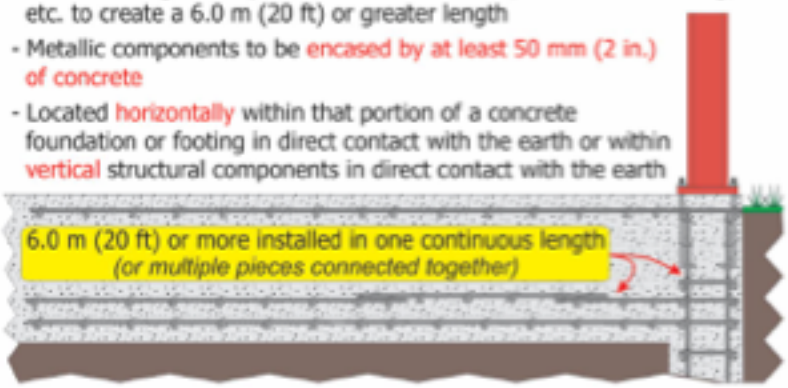




250.52(A)(3) Concrete-Encased Electrode

Concrete-encased electrode to consist of:

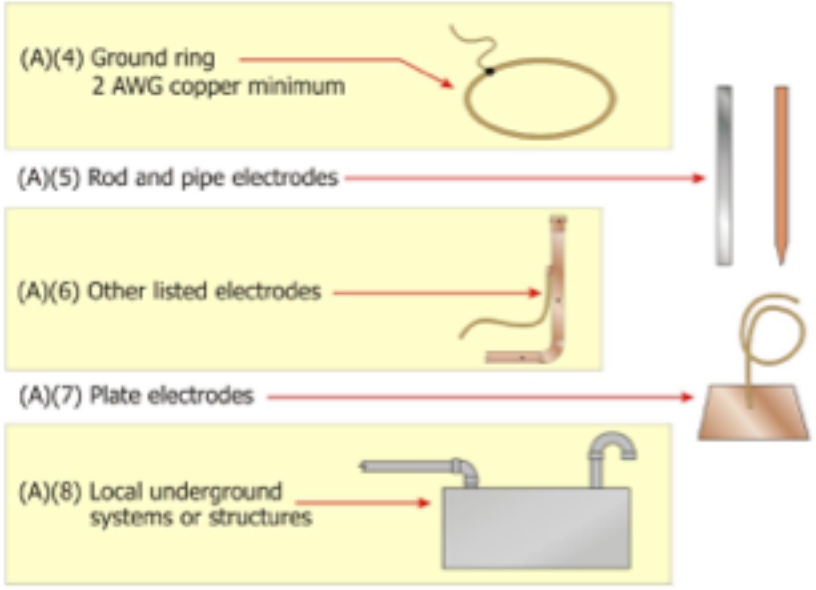
- At least 6.0 m (20 ft) of bare copper conductor not smaller than 4 AWG or one or more bare or electrically conductive coated steel reinforcing bars or rods, not less than 13 mm (½ in.) in diameter,
- Installed in one continuous 6.0 m (20 ft) length, or multiple pieces connected together by the usual steel tie wires, exothermic welding, etc. to create a 6.0 m (20 ft) or greater length
- Metallic components to be encased by at least 50 mm (2 in.) of concrete
- Located horizontally within that portion of a concrete foundation or footing in direct contact with the earth or within vertical structural components in direct contact with the earth



Grounding Electrode Required

- Where the grounding electrodes described in 250.52(A) are not present, a grounding electrode must be installed
- Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) shall be installed and used
- These "made" electrodes can consist of rod, pipe, and plate electrodes, or other listed electrodes, or local metal underground systems or structures
- See 250.50 and 250.52(A)(4) through (A)(8)

250.52(A) Installed Grounding Electrodes



Ground Ring

- The requirements or conditions a **ground ring** must meet to qualify as a grounding electrode are as follows:
  - Encircles the building or structure
  - Must be in direct contact with the earth
  - Consist of at least 6.0 m (20 ft) of bare copper conductor
  - Not smaller than 2 AWG
- See 250.52(A)(4)

Rod or Pipe Electrodes

- Requirements or conditions a **rod and pipe electrode** must meet to qualify as a grounding electrode are as follows:
  - Not be less than 2.44 m (8 ft) in length
  - **Pipe or conduit grounding electrodes** must consist of the following materials:
    - Not smaller than metric designator 21 (trade size ¾)
    - Where of steel, outer surface must be galvanized or otherwise metal-coated for corrosion protection
- See 250.52(A)(5)

Rod or Pipe Electrodes *(cont.)*

- Requirements or conditions a **rod and pipe electrode** must meet to qualify as a grounding electrode are as follows:
  - Not be less than 2.44 m (8 ft) in length
  - **Rod-type grounding electrodes** must consist of the following materials:
    - Stainless or copper or zinc coated steel
    - At least 15.87 mm (⅝ in.) in diameter, unless listed
- See 250.52(A)(5)

250.52(A)(6) Other Listed Electrodes

Other listed grounding electrodes shall be permitted to be used such as a chemical ground electrode system

Required to be listed as grounding and bonding equipment [UL 467]

Plate Electrodes

- Requirements or conditions a **plate electrode** must meet to qualify as a grounding electrode are as follows:
  - Must expose not less than 0.186 m^2 (2 ft^2) of surface to exterior soil *(1 ft sq. plate has two sides and would comply)*
  - Bare or electrically conductive coated iron or steel plates must be at least 6.4 mm (¼ in.) in thickness
  - Solid, uncoated electrodes of nonferrous metal shall be at least 1.5 mm (0.06 in.) in thickness
- See 250.52(A)(7)
- Required to be buried not less than **762 mm (2 ½ ft)** below the surface of the earth *[see 250.53(H)]*

Other Local Metal Underground Systems or Structures as Electrodes

- If none of the grounding electrodes described at 250.52(A)(1 through (A)(7) are present at the building or structure, "**other local metal underground systems or structures**" are permitted to be used in the grounding electrode system
- This could include such things as:
  - Piping systems
  - Underground tanks
  - Underground well casings that are not bonded to a metal water piping system(s)
- See 250.50 and 250.52(A)(8)

Supplemental Electrode

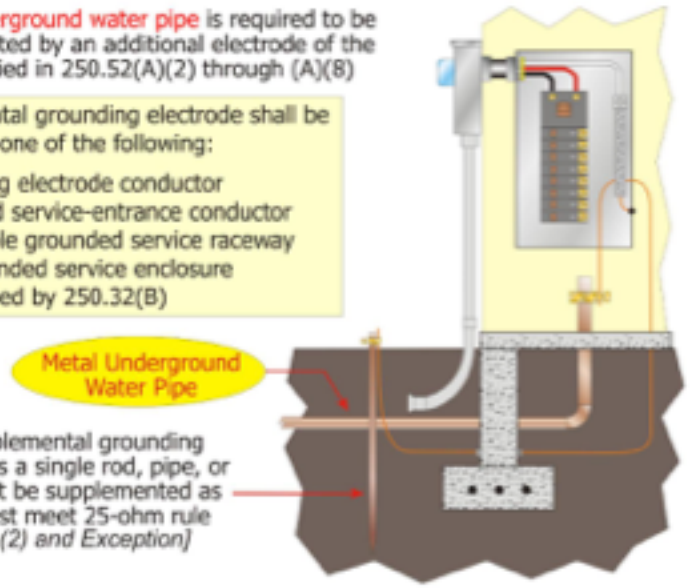
- An **underground metal water pipe** electrode is required to be supplemented by an additional grounding electrode
- Any of the electrodes described in 250.52(A)(2) through (A)(8) are permitted to be used *(not limited to just a ground rod)*
- If the supplemental electrodes are of the rod, pipe, or plate types, these must be supplemented as well or must meet the 25 ohm rule at 250.53(A)(2), Exception
- See 250.53(D)(2)

250.53(D)(2) Supplemental Electrode Connection

Metal underground water pipe is required to be supplemented by an additional electrode of the type specified in 250.52(A)(2) through (A)(8)

Supplemental grounding electrode shall be bonded to one of the following:

- Grounding electrode conductor
- Grounded service-entrance conductor
- Nonflexible grounded service raceway
- Any grounded service enclosure
- As provided by 250.32(B)



Size of Bonding Jumper for Grounding Electrode System

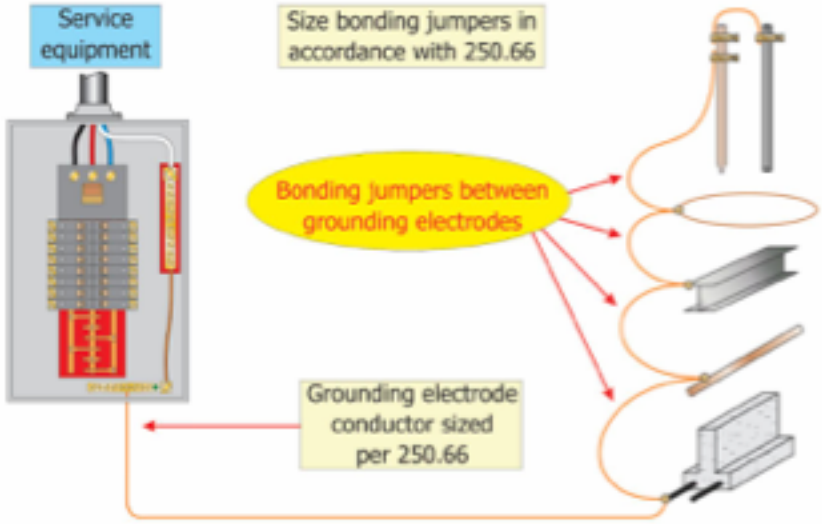
- **Bonding jumper(s)** used to connect grounding electrodes of the grounding electrode system together required to be installed in accordance with the requirements of 250.64(A), (B), and (E)
- Bonding jumper(s) used to bond grounding electrodes together required to be sized in accordance with 250.66
- Sizes based on the size of ungrounded service-entrance conductors
- Connections to be made in a manner specified in 250.70
- See 250.53(C)

Size of Bonding Jumper for Grounding Electrode System *(cont.)*

- Conductor(s) connecting grounding electrodes together is a **bonding conductor** *(not a grounding electrode conductor)*
- These bonding conductors not required to be installed in "one continuous length" *(as per grounding electrode conductors)*
- Conditions for sizing the grounding electrode conductor at **250.66(A), (B), and (C)** apply for sizing of these bonding jumpers

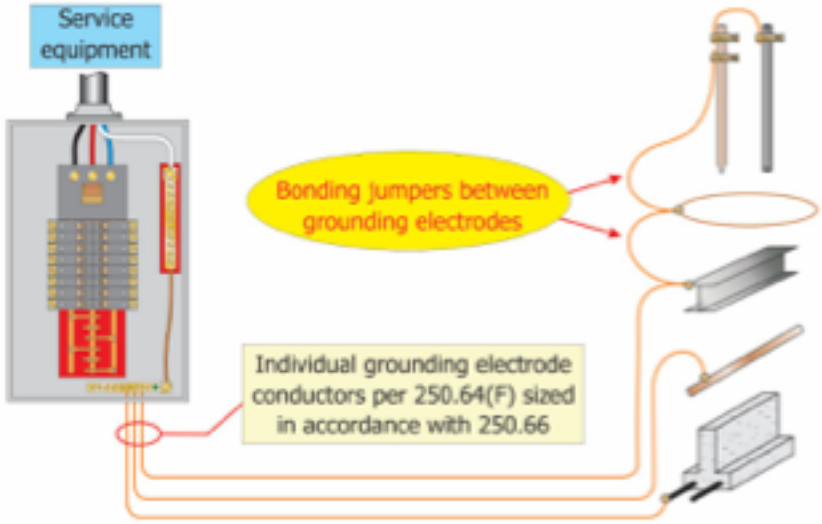
Bonding Jumper(s) for Grounding Electrode System

Grounding electrodes connected together with bonding jumpers that are installed in accordance with 250.64(A), (B), and (E)



Individual Grounding Electrode

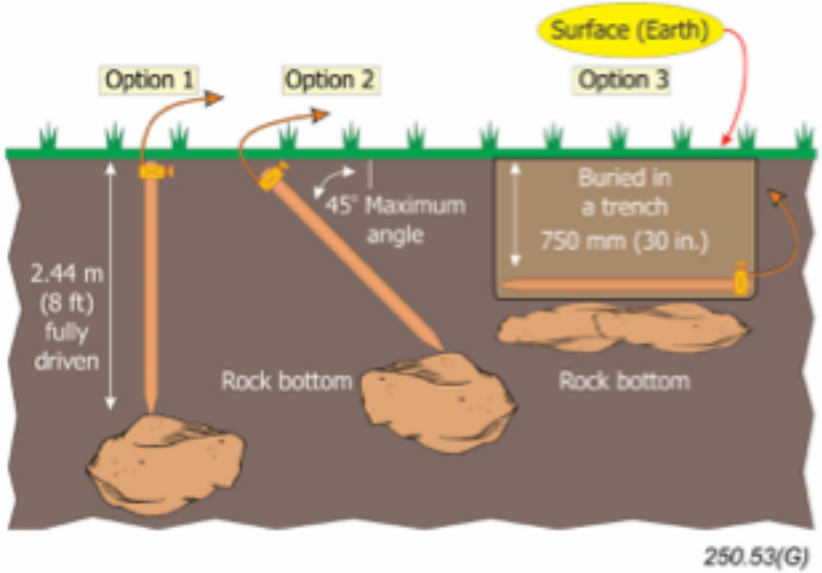
Individual grounding electrode conductor(s) are permitted to be run to any convenient grounding electrode in the grounding electrode system



Installation of Rod and Pipe Electrodes

- **Rod and pipe electrodes** required to be installed with least **2.44 m (8 ft)** is in contact with the soil
- Required to be **driven vertically** unless rock bottom is encountered
- If rock bottom is encountered *(preventing rod or pipe from being driven **2.44 m (8 ft)** vertically)*, rod or pipe permitted to be installed at an **oblique angle** of not more than **45 degrees** from vertical
- Where driven at an angle cannot be achieved, only then can the rod or pipe be **buried in a trench** that is at least **750 mm (30 in.)** deep
- See 250.53(G)

Installation of Rod or Pipe Electrodes

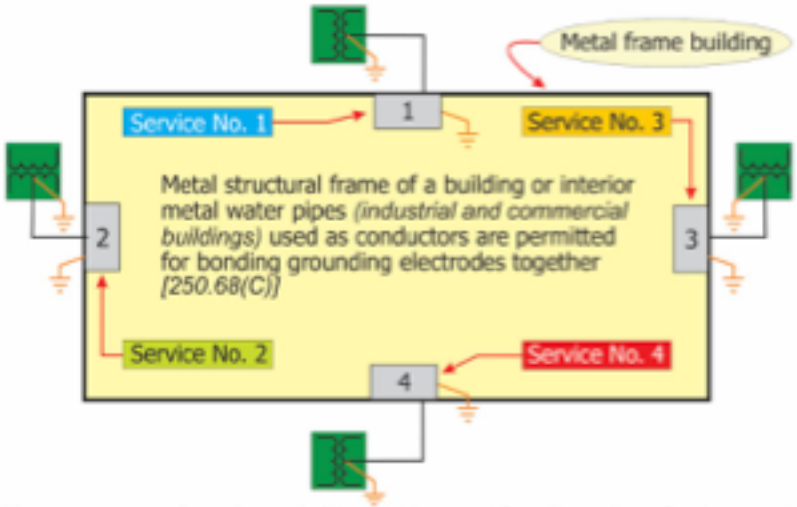


250.53(G)

Common Grounding Electrode

- Where more than one service supplies a building or structure, often there are more than one utility transformer or source *(which can have differences of potential between them)*
- Where more than one service are installed in the same building or structure, they must use the same grounding electrode system
- **Common grounding electrode** required to be used for all ac system grounding in or at a building or structure
- Where two or more grounding electrodes are bonded together, considered to be a **single grounding electrode system**
- See 250.58 and 250.50

250.58 Common Grounding Electrode

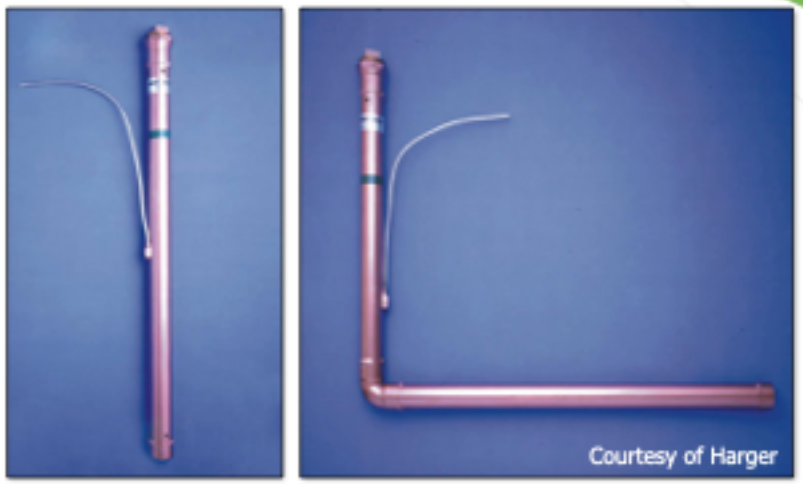


The same grounding electrode(s) must be used for all services, feeders, and branch circuits. Two or more electrodes bonded together are considered one grounding electrode system [250.58]

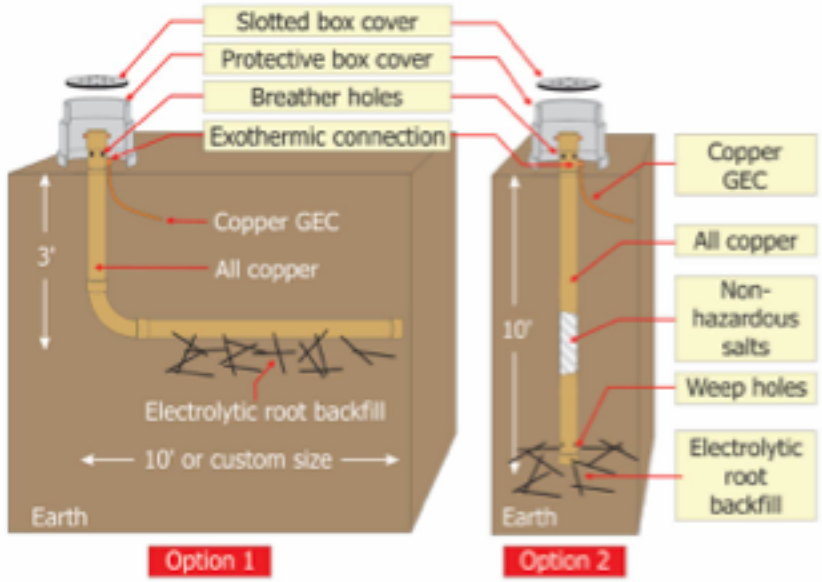
Enhanced Grounding Electrodes

- Minimum requirements for grounding electrodes for use in grounding services, systems, and equipment are covered in Part III of Article 250
- Ever-increasing installations using **information technology equipment** and **sensitive electronics** sometimes drive the need to exceed the minimum requirements established for safety of persons and property
- Installing electrodes or electrode systems that are extensive in nature and designed to establish and maintain a **lower level of resistance** to earth through the electrode or electrode system can accomplish this need
- Listed products are available to accomplish this additional grounding when desired for the electrical system
- Provisions for **other listed electrodes** are addressed at 250.52(A)(6)

Enhanced Grounding Electrodes



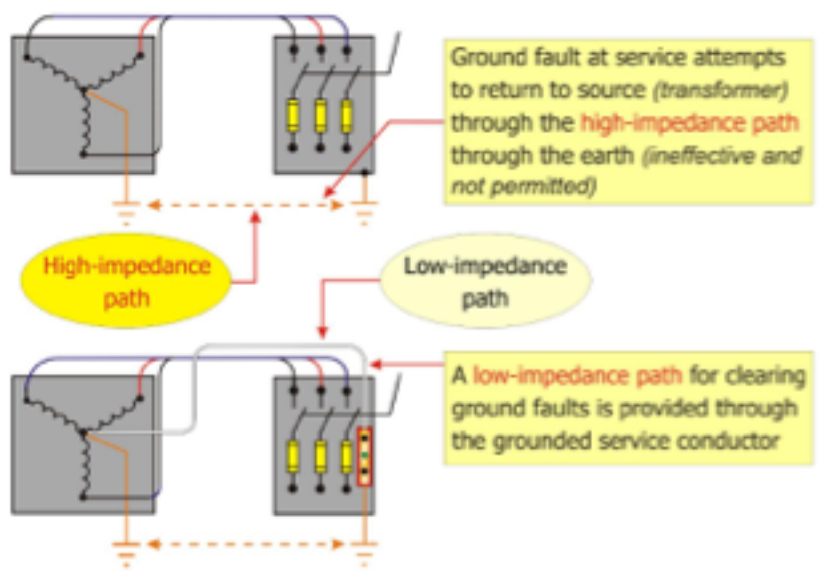
Enhanced Grounding Electrode - Anatomy



Earth Prohibited as Return Path

- In discussing grounding electrodes, notice that no mention is made for providing a low-resistance, low-impedance common grounding electrode path for clearing ground faults
- The high impedance of the earth makes it an **ineffective path** for the levels of current common to power systems
- The earth should never be used as a ground fault current path, as it is a very poor conductor
- See 250.4(A)(5)

250.4(A)(5) Earth Return Prohibited



Resistance of Grounding Electrodes

- No requirement in the *Code* that all grounding electrodes meet any maximum resistance to ground
- It is expected that the grounding electrode system will have a resistance to ground of **25 ohms or less**
- The *Code* specifies a resistance of 25 ohms or less ***only*** for single rod, pipe, or plate electrode(s)
- Where the resistance of a single rod, pipe, or plate electrode exceeds 25 ohms, required to be **supplemented** by an additional electrode *(other than a metallic water pipe electrode)*

Resistance of Grounding Electrodes *(cont.)*

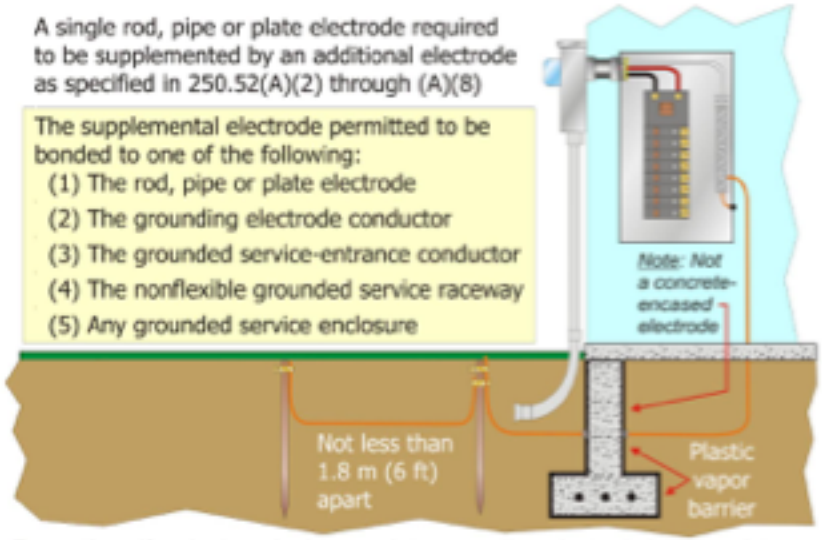
- Rod, pipe and plate electrodes must be **supplemented** by additional electrode *[250.53(A)(2)]*
- Exception provides that where a single rod, pipe, or plate electrode has a resistance to ground of **25 ohms or less** then no supplemental electrode is required
- Where driven ground rods are installed, two ground rods would be the maximum required under any condition
- No requirement that additional electrodes *(such as ground rods or plates)* be installed until the 25 ohms-to-ground resistance is obtained

250.53(A) Rod, Pipe, and Plate Electrodes

A single rod, pipe or plate electrode required to be supplemented by an additional electrode as specified in 250.52(A)(2) through (A)(8)

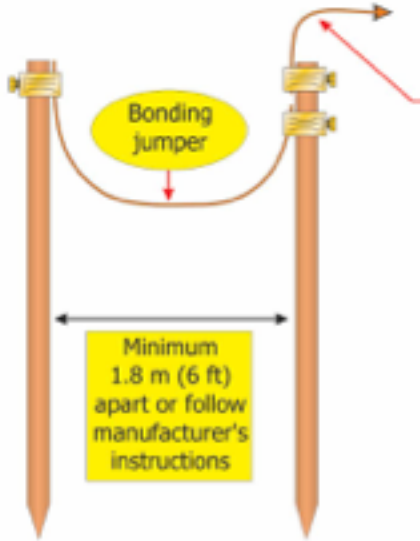
The supplemental electrode permitted to be bonded to one of the following:

(1) The rod, pipe or plate electrode
(2) The grounding electrode conductor
(3) The grounded service-entrance conductor
(4) The nonflexible grounded service raceway
(5) Any grounded service enclosure



Exception: *If a single rod, pipe, or plate grounding electrode has a resistance to earth of* ***25 ohms or less****, the supplemental electrode shall not be required*

Resistance of Rod, Pipe, and Plate Electrodes

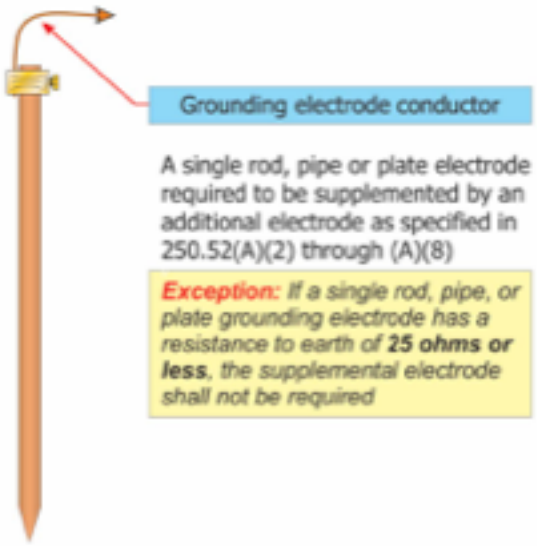


Grounding electrode conductor

A single rod, pipe or plate electrode required to be supplemented by an additional electrode as specified in 250.52(A)(2) through (A)(8)

No resistance measurement required for rod, pipe, and plate electrodes after these electrodes have been supplemented

Resistance of Rod, Pipe, and Plate Electrodes



A single rod, pipe or plate electrode required to be supplemented by an additional electrode as specified in 250.52(A)(2) through (A)(8)

Exception: *If a single rod, pipe, or plate grounding electrode has a resistance to earth of* ***25 ohms or less****, the supplemental electrode shall not be required*

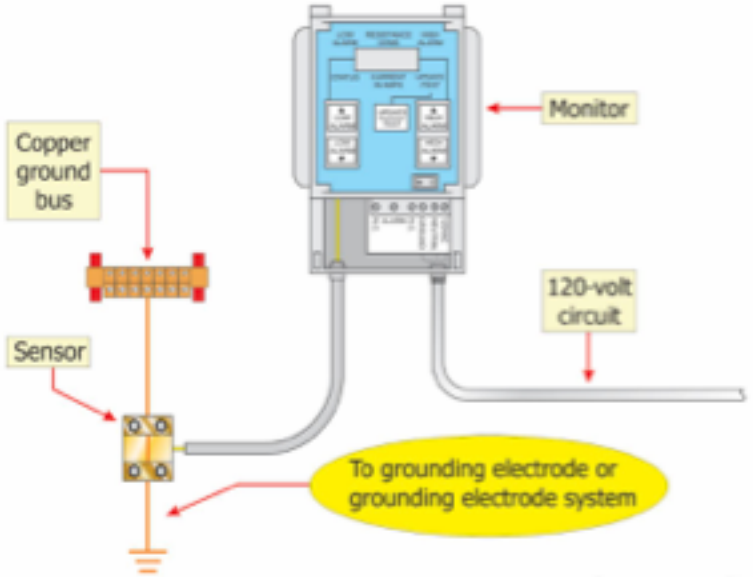
Ground Electrode System Monitoring

- **Grounding electrode system monitoring** has become common where **information technology equipment** and other **sensitive electronic equipment** are utilized
- Not required by the *Code*
- Often desired as an **essential performance option** for data centers and similar facilities
- Measures grounding system performance on an ongoing basis
- Provides an early warning of ground system degradation or loss of integrity so remedial action can be taken
- Grounding is an integral part of safety as well as center of lightning protection and surge suppression systems

Ground Electrode System Monitoring *(cont.)*

- Features of **grounding electrode system monitoring systems** include but are not limited to:
  - Ongoing monitoring of ground system resistance and current
  - Remote reading and control capability
  - Local audible alarm
  - High and low alarm values
  - Adjustable sampling rate

Ground Resistance Monitor System

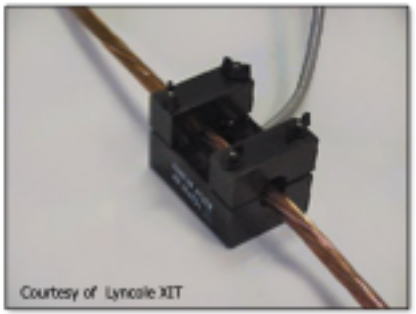


Concept courtesy of Lyncole XIT

Ground Electrode System Monitoring

Monitor

Sensor



Ground Electrode Resistance

- Grounding electrodes maintain a reference potential for:
  - Instrument safety
  - Protect against static electricity,
  - Limit the system-to-frame voltage for operator safety
- Ground resistance should be zero ohms *(ideally)*
- Low ground resistance is essential to meet *NEC*, OSHA, and other electrical safety standards

Ground Electrode Resistance *(cont.)*

- Resistance of the electrode has the following components:
  - Resistance of the metal and that of the connection to it
  - Contact resistance of the surrounding earth to the electrode
  - Resistance in the surrounding earth to current *(earth resistivity)*, which is often the most significant factor

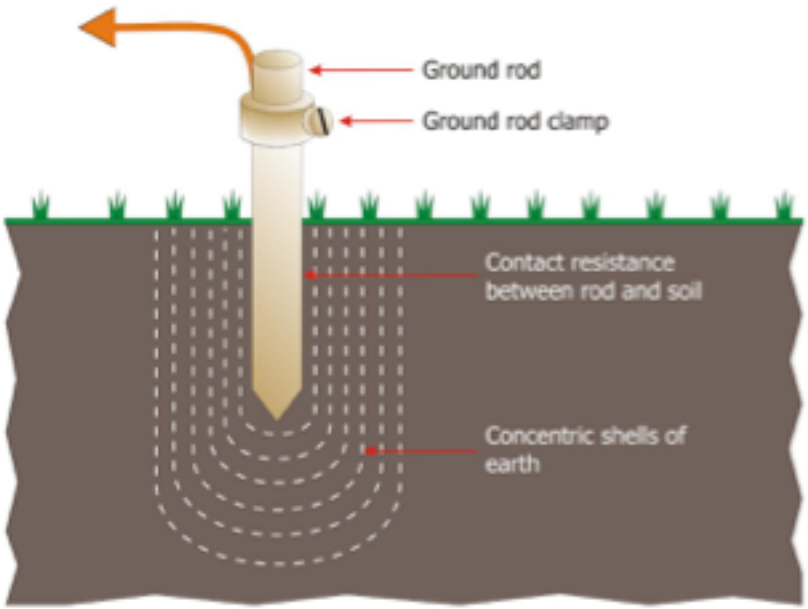
Ground Electrode Resistance *(cont.)*

- Grounding electrodes are usually made of very conductive material with adequate cross sections so overall resistance is negligible
  - Copper, copper clad, or zinc plated *(galvanized)*
- NIST *(National Institute of Standards and Technology)* has demonstrated that resistance between the surrounding earth and the electrode is negligible if electrode is:
  - Free of paint, grease or other coating and…
  - Earth is firmly packed

Ground Electrode Resistance *(cont.)*

- The electrode can be thought of as being surrounded by **concentric shells of earth** or soil, all of the same thickness
- Closer the shell is to the electrode, the smaller its surface ***(greater its resistance)***
- Farther away the shells are from the electrode, the greater the surface of the shell ***(lower the resistance)***

Ground Rod Resistance



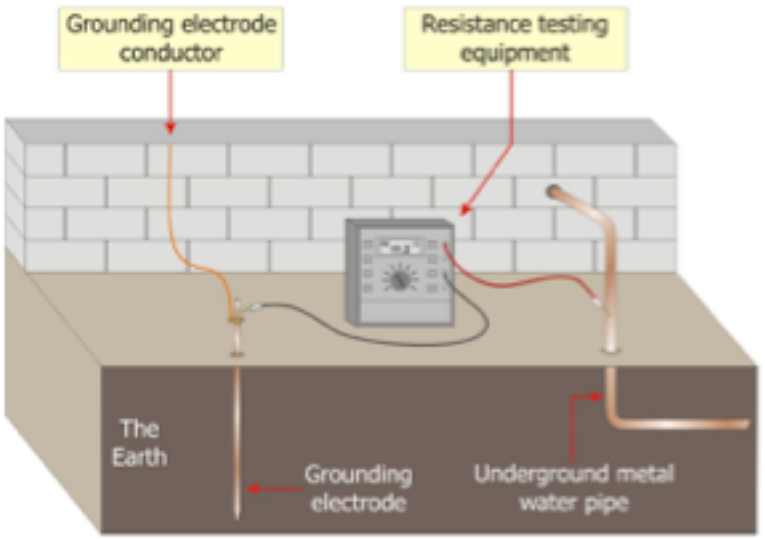
Maximum Resistance of Grounding Electrodes

- No maximum resistance for a grounding electrode system
- Maximum **25 ohms** for single electrodes of the rod, pipe, or plate types when not supplemented *[250.53(A)(2), Ex.]*
- Rod, pipe, or plate electrode required to be supplemented by an additional electrode
- When supplemented, no maximum earth resistance for the rod, pipe, or plate electrode(s) *(no 25 ohms rule)*

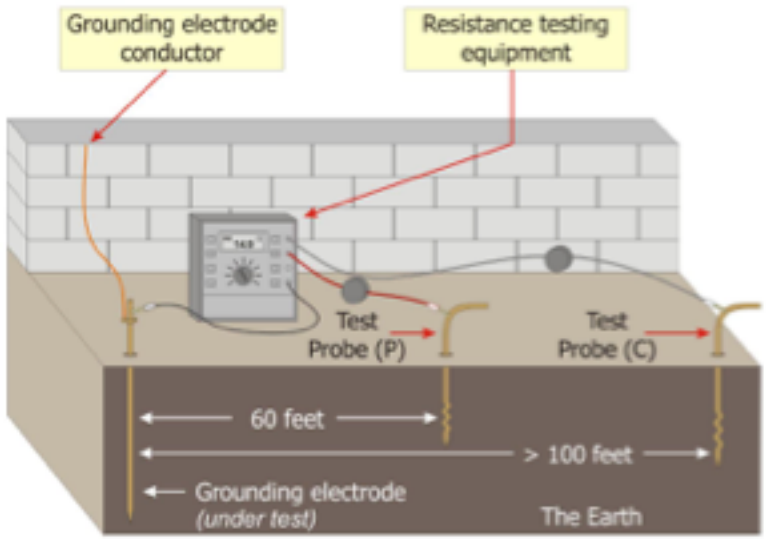
Grounding Electrode Resistance Testing

- Measurement of ground resistances can only be accomplished with specially designed test equipment
- Most ground resistances instruments use the **fall-of-potential principle** of alternating current (ac) circulating between an auxiliary electrode and the grounding electrode under test
- Reading will be given in ohms
- Ohms represent the resistance of the ground electrode to the surrounding earth
- Some manufacturers of earth resistance testing instruments have recently introduced clamp-on ground resistance testers

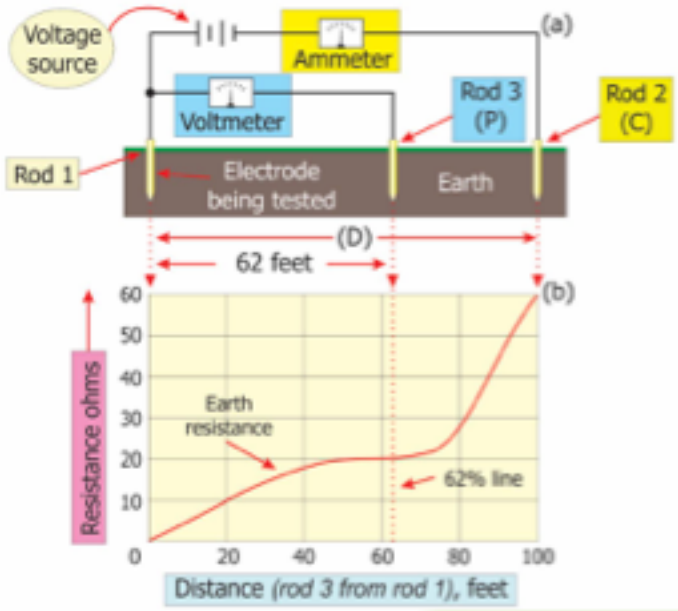
Two-Point Resistance Measurement Method



Three-Point Fall-of-Potential Test Method



Principles of Earth Testing



Ground Resistance Clamp-on Tester

- Digital earth test clamp
- Courtesy of Megger

Objectionable Currents

- The term ***objectionable current*** is not defined
- Steps permitted to correct objectionable currents:
  - Due to multiple grounding connections, abandon one or more, but not all
  - Change location of grounding connection
  - Interrupt continuity of grounding conductor or conductive path causing the objectionable current
  - Other means acceptable to the authority having jurisdiction
- See 250.6

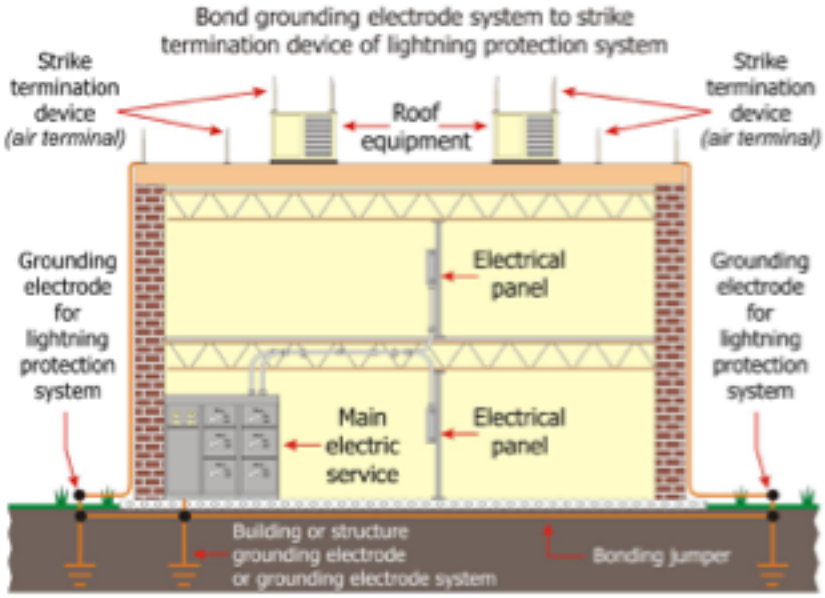
Lightning Protection System

- Lightning protection systems should be installed in accordance with **NFPA-780, *Standard for the Installation of Lightning Protection Systems***
- The *Code* prohibits the use of driven pipes, rods, or other electrodes installed for connection of the lightning protection conductors and strike termination devices in place of the grounding electrodes required for a wiring system and for equipment
- See 250.60

Lightning Protection System *(cont.)*

- Note that where two grounding electrodes are installed, they are required to be bonded together
- Lightning protection grounding electrode system *required* be bonded to the building or structure power grounding electrode system
- See 250.106

Bonding of Grounding Systems Together



Chapter Seven:
Grounding Electrode Conductors

- General requirements and definitions for grounding electrode conductors
- Functions of the grounding electrode conductor
- Sizing grounding electrode conductors
- Grounding electrode conductor installation
- Grounding electrode conductor connections
- Material and protection for grounding electrode conductors

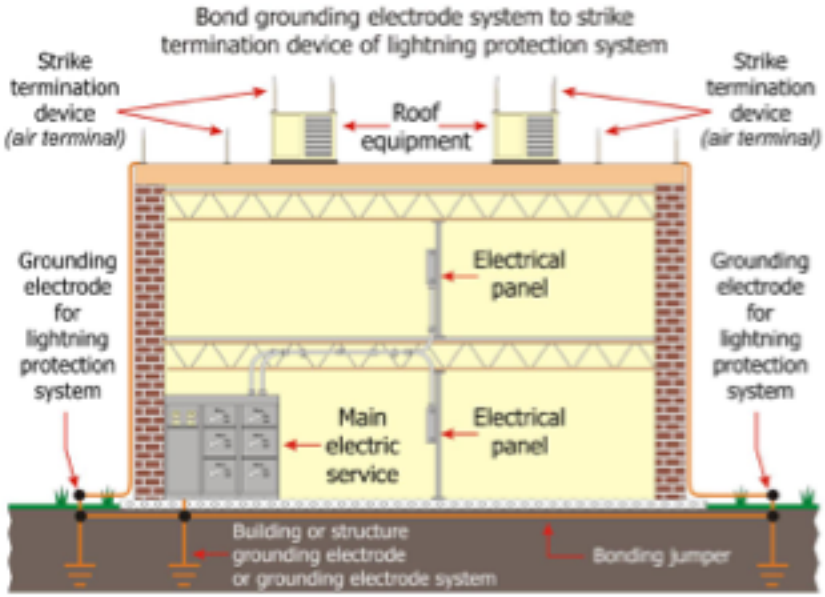
Grounding Electrode Conductors

- ***Grounding electrode conductors*** used to connect the following to a grounding electrode or a point on grounding electrode system:
  - Electrical system grounded conductor
  - Equipment grounding conductor
  - or both,
- Required to be sized per Table 250.66 based on size of the service-entrance conductors or largest derived ungrounded conductors of a separately derived system
- Not required to exceed **3/0 AWG copper** or **250-kcmil aluminum** or copper-clad aluminum

Grounding Electrode Conductors *(cont.)*

- Specific requirements for ***grounding electrode conductors*** given regarding:
  - Conductor material
  - Installation procedures
  - Protection from physical damage
  - Connection procedures

Bonding of Grounding Systems Together



Chapter Seven:
Grounding Electrode Conductors

- General requirements and definitions for grounding electrode conductors
- Functions of the grounding electrode conductor
- Sizing grounding electrode conductors
- Grounding electrode conductor installation
- Grounding electrode conductor connections
- Material and protection for grounding electrode conductors

Grounding Electrode Conductors

- ***Grounding electrode conductors*** used to connect the following to a grounding electrode or a point on grounding electrode system:
  - Electrical system grounded conductor
  - Equipment grounding conductor
  - or both,
- Required to be sized per Table 250.66 based on size of the service-entrance conductors or largest derived ungrounded conductors of a separately derived system
- Not required to exceed **3/0 AWG copper** or **250-kcmil aluminum** or copper-clad aluminum

Grounding Electrode Conductors *(cont.)*

- Specific requirements for ***grounding electrode conductors*** given regarding:
  - Conductor material
  - Installation procedures
  - Protection from physical damage
  - Connection procedures

Definitions

- ***Grounding Electrode Conductor:*** A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

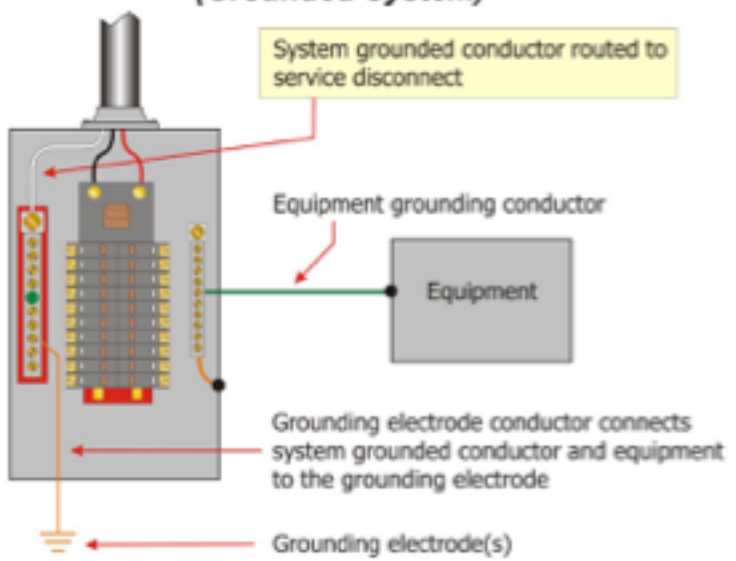
Function of Grounding Electrode Conductor

- In a **grounded system**, GEC is the sole connection from the grounding electrode to the grounded system conductor *(may be a neutral)* and the equipment grounding conductor(s)
- For an **ungrounded system**, sole connection from the grounding electrode to the service equipment or building disconnect enclosure and to the equipment grounding conductor(s)
- See 250.24(A), (D), and (E)

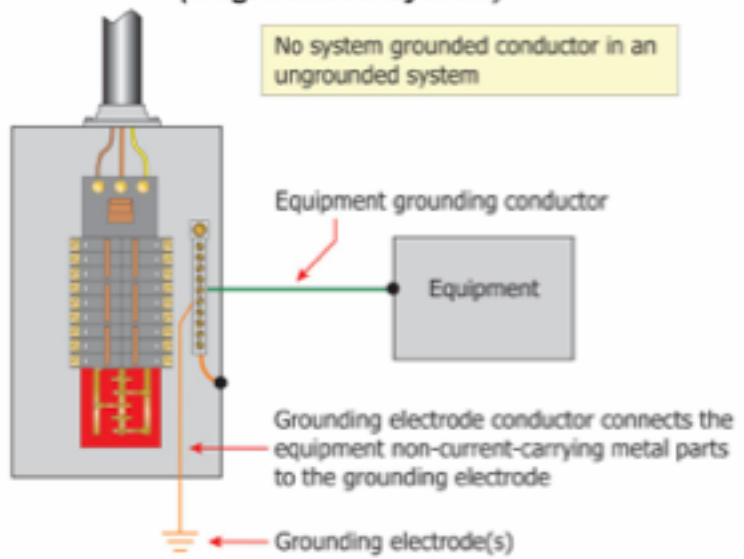
Function of Grounding Electrode Conductor *(cont.)*

- A **single grounding electrode conductor** is required to connect both the system grounded conductor and the equipment grounding conductor
- Example: one grounding electrode conductor cannot be used to ground the system grounded conductor and a second grounding electrode conductor be used to ground the equipment grounding conductor *(even though both grounding electrode conductors are connected to the same grounding electrode)*

Grounding Electrode Conductor *(Grounded System)*



Grounding Electrode Conductor
(Ungrounded System)



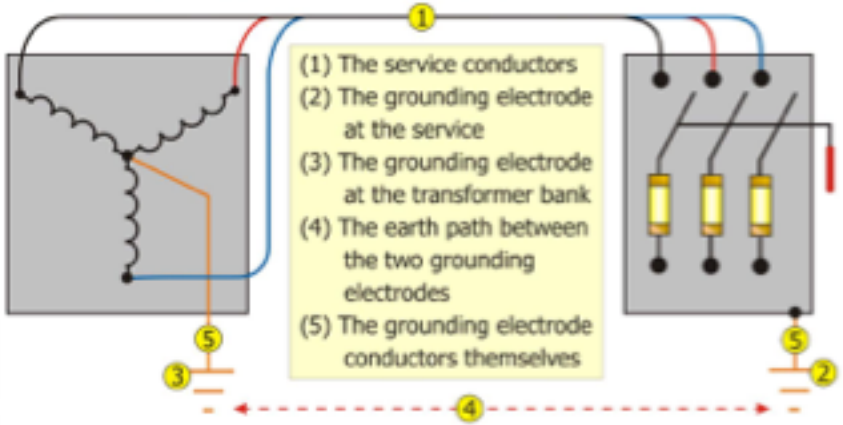
Current in Grounding Electrode Conductor

- The maximum amount of current in a grounding electrode conductor is directly related to the **impedance** in the ground return path to the source
- Dependent on the sum of **resistance** in ground return path:
  - Grounding electrode conductor *(service) plus*
  - Grounding electrode *(service) plus*
  - Earth *plus*
  - Grounding electrode *(source) plus*
  - Grounding electrode conductor *(source)*
- GEC has little or no effect in clearing ground faults

High Impedance Earth Return

Maximum current of ground fault is limited by the high-impedance series circuit through grounding electrodes and the earth

Ground-fault circuits consist of the resistance of:



Higher impedance in the path results in a lower amount of current over that particular path back to the source

Sizing Grounding Electrode Conductors

- The minimum size of the grounding electrode conductor is based on the largest ungrounded service-entrance conductor or derived phase conductor from a separately derived system
- Refer to 250.66 and Table 250.66
- Scan down left column and find the size of the service-entrance conductor being installed
- Scan across the row to find the size of copper, aluminum, or copper-clad aluminum grounding electrode conductor

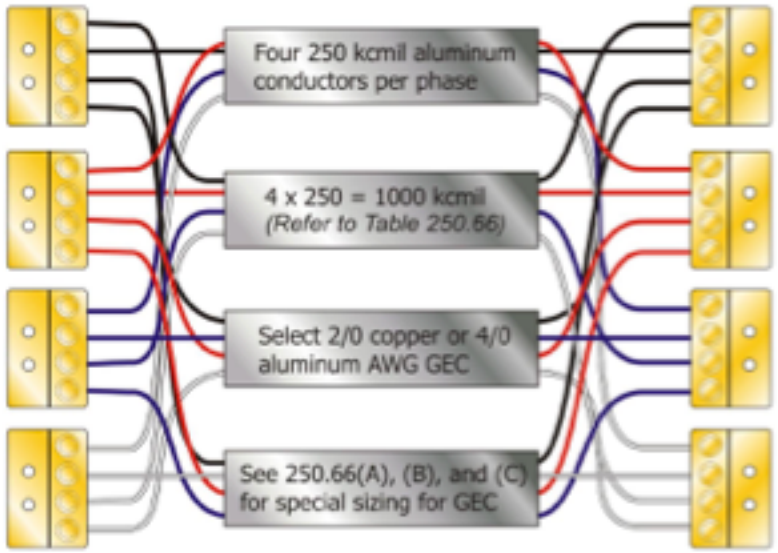
Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

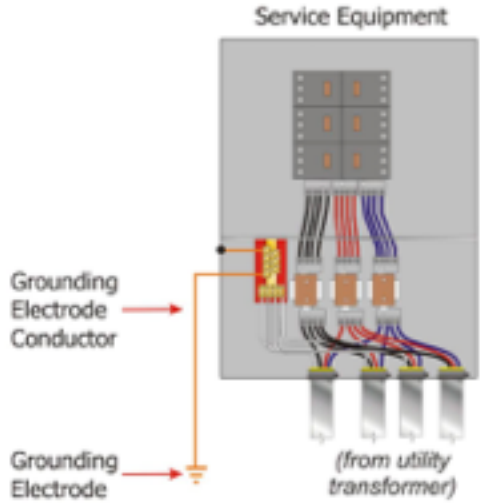
Sizing Grounding Electrode Conductors

- Where service-entrance **conductors are installed in parallel** as allowed by 310.10(H), the circular mil area of one set of parallel conductors is added together and treated as a single conductor for purposes of sizing GEC
- **Example:** Four 250-kcmil aluminum service-entrance conductors installed in parallel are considered to be a single 1000-kcmil aluminum conductor
- Reference Table 250.66 for sizing of GEC for this set of service-entrance conductors

Grounding Electrode Conductor for Parallel Service-Entrance Conductors



Grounding Electrode Conductor for Parallel Service-Entrance Conductors



4- 250 Kcmil aluminum conductors per phase

4 X 250= 1000 Kcmil *(refer to Table 250.66)*

Select 2/0 copper or 4/0 aluminum AWG grounding electrode conductor *(GEC)*

See 250.66(A),(B) or (C) for special sizing requirments for GEC

Sizing Grounding Electrode Conductors

- Grounding electrode conductors are generally required to be not smaller than the values in Table 250.66
- Grounding electrode conductor or bonding jumper may be sized as follows where not extended on to other types of electrodes that require a larger size conductor:
  - Not required to be larger than 6 AWG copper or 4 AWG aluminum to **rod, pipe, or plate** type grounding electrodes *[250.66(A)]*
  - Not required to be larger than 4 AWG copper to **concrete-encased electrode** *[250.66(B)]*
  - Not larger than the **ground ring** conductor *[250.66(C)]*

Sizing Grounding Electrode Conductors *(cont.)*

- Bare aluminum conductors are not permitted where installed in direct contact with masonry or earth, or where subject to corrosive conditions *[250.64(A)]*
- Aluminum grounding electrode conductor terminations are not allowed within 450 mm (18 in.) of the earth *[250.64(A)]*

Sizing at Multiple Service Disconnects

- Three methods permitted by the *NEC* for connections of grounding electrode conductor taps to a **common grounding electrode conductor** where multiple service disconnects are installed [250.64(D)(1), (2), and (3)]
  - Taps to common grounding electrode conductor
  - Individual conductors to grounding electrode(s)
  - Connection at common location

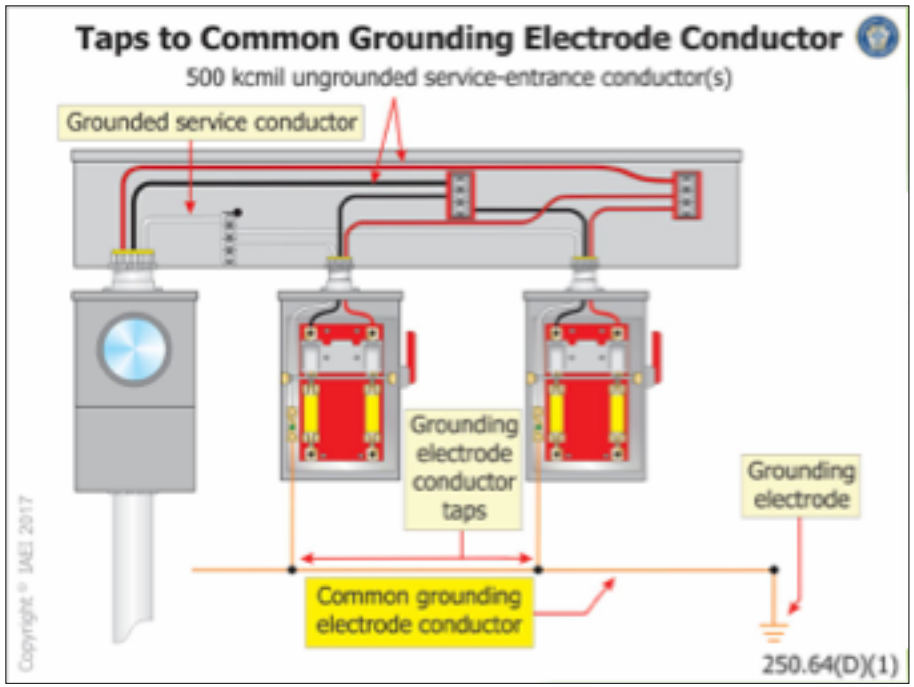
Sizing Common Grounding Electrode Conductor and Taps

- Single GEC permitted to serve separate enclosures
- Common GEC sized based on main service-entrance conductors
- Tap conductors sized based on individual service-entrance conductors supplying each service disconnect *(connected from each service disconnect to the common grounding electrode)*
- See 250.64(D)(1)

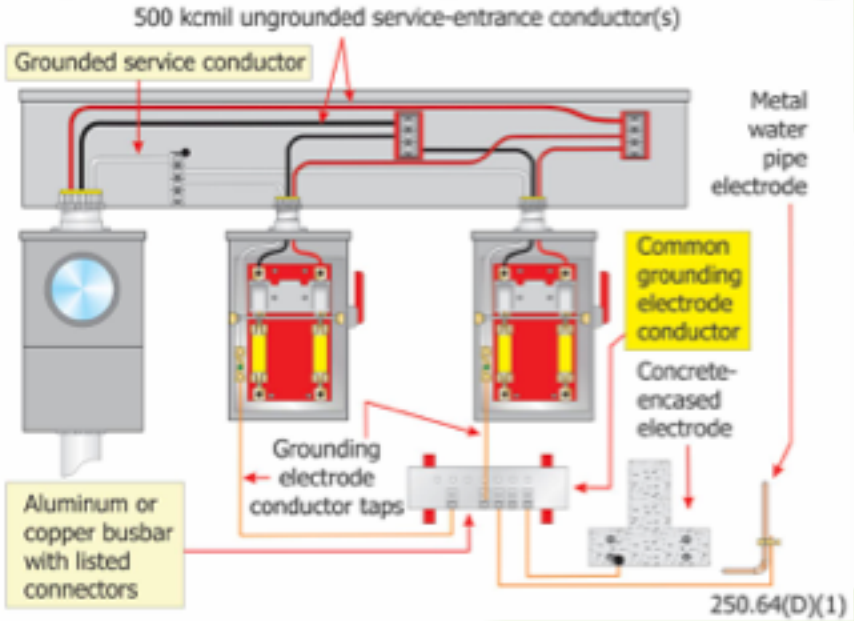
Sizing Common Grounding Electrode Conductor and Taps *(cont.)*

- Important to understand alternative provided at 250.64(D)(1) addresses two conductors;
  - **Common grounding electrode conductor**
    - Required to be installed without a splice or joint *(generally)*
  - **Grounding electrode conductor tap(s)**
    - Permitted to be connected to the common grounding electrode conductor

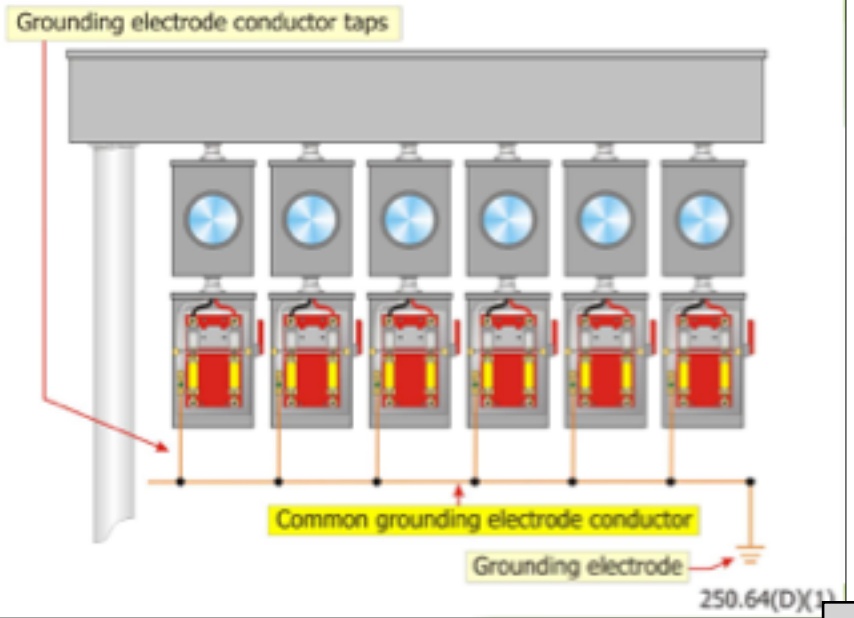
Taps to Common Grounding Electrode Conductor



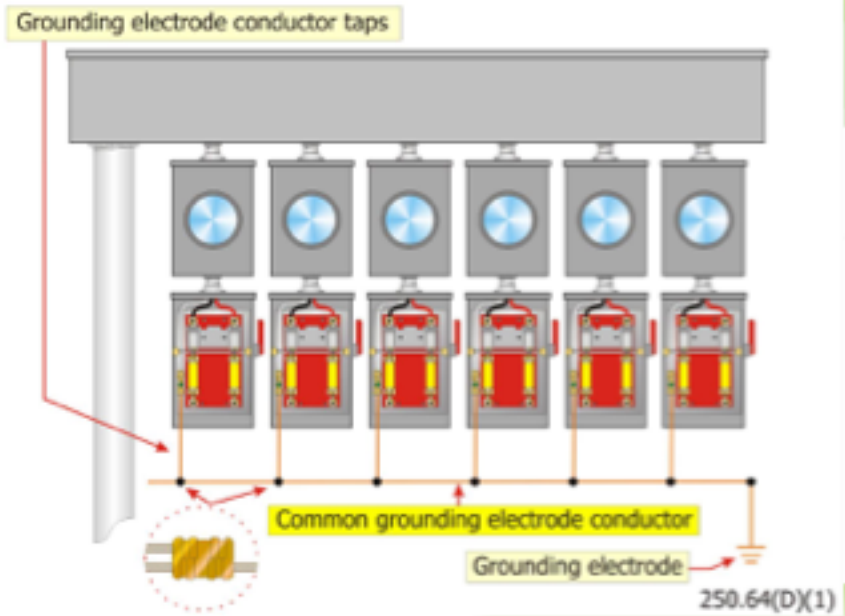
Taps to Common Grounding Electrode Conductor



Taps to Common Grounding Electrode Conductor



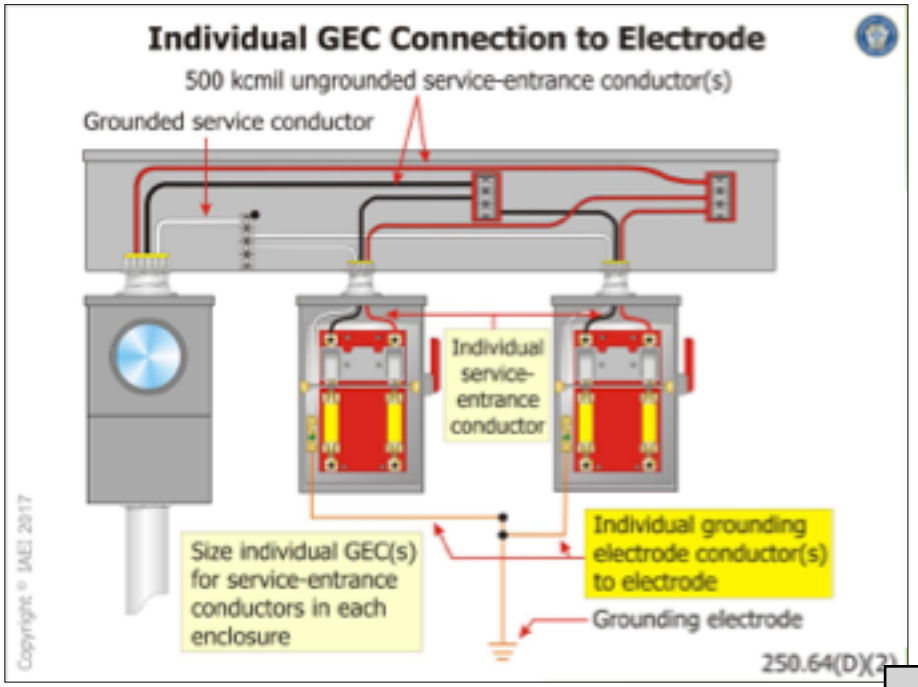
Taps to Common Grounding Electrode Conductor



Sizing Individual Grounding Electrode Conductors

- Permitted to install grounding electrode conductor from **individual service disconnects** to grounding electrode *(rather than being tapped to the common grounding electrode conductor)*
- Grounding electrode conductor sized for the service-entrance conductor serving each individual enclosure
- See 250.64(D)(2)

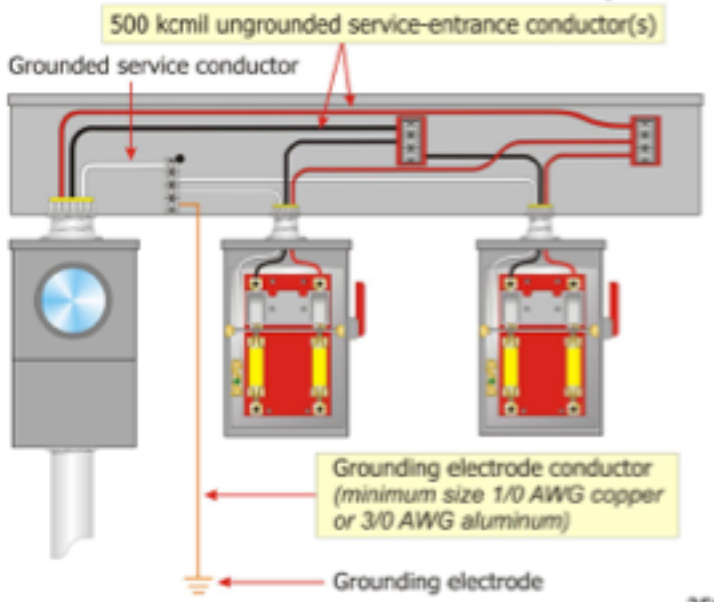
Individual GEC Connection to Electrode



Sizing at Common Location

- Permitted to install a **single grounding electrode conductor** to wireway or other **common location** to all connected individual service entrance conductors
- Example:
  - 500-kcmil copper service-entrance conductors with grounded conductor grounded inside the wireway
  - GEC to a water pipe or metal in-ground building steel electrode required to be 1/0 AWG copper or 3/0 AWG aluminum *(Table 250.66)*
- See 250.64(D)(3)

GEC Connection in Common Location *(Wireway)*



250.64(D)(3)

Grounding Electrode Conductor Connections

- The *Code* generally requires that the point of connection of grounding electrode conductors and bonding jumpers to grounding electrodes be made **accessible** *[see 250.68(A)]*
  - **Two exceptions** to this accessibility rule
- GEC connection must be made in a manner that will ensure a permanent and effective grounding path

Grounding Electrode Conductor Connections *(cont.)*

- All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode are generally required to be accessible
- An **encased or buried connection** to a concrete-encased, driven, or buried grounding electrode is **not required to be accessible** by **250.68(A) Ex. No. 1**

Grounding Electrode Conductor Connections

Photo shows two different ground clamps that are permitted to be buried or concrete-encased *(not accessible)* as allowed by 250.68(A) Ex. No. 1

Grounding Electrode Conductor Connections *(cont.)*

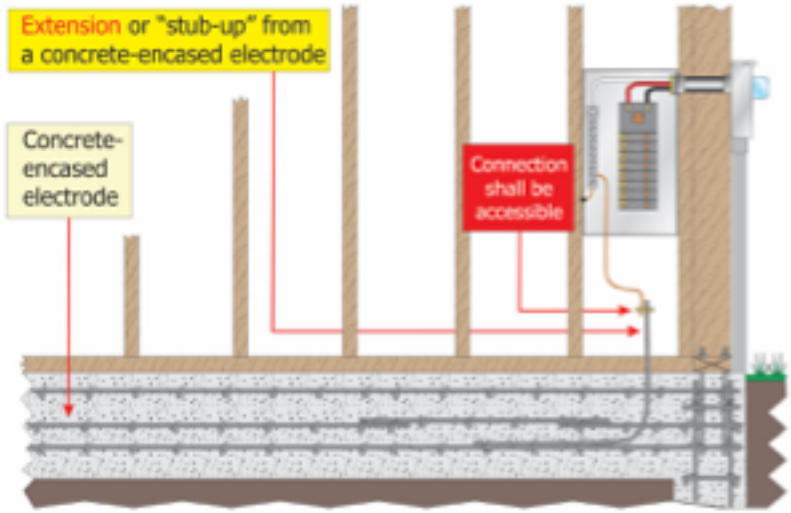
- All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode are generally required to be accessible
- **Exothermic or irreversible compression connections** used at terminations, together with the mechanical means used to attach such terminations to **fireproofed structural metal** whether or not the mechanical means is reversible, is **not required to be accessible** by 250.68(A) Ex. No. 2

GEC Connections from Extension at Concrete-Encased Electrode

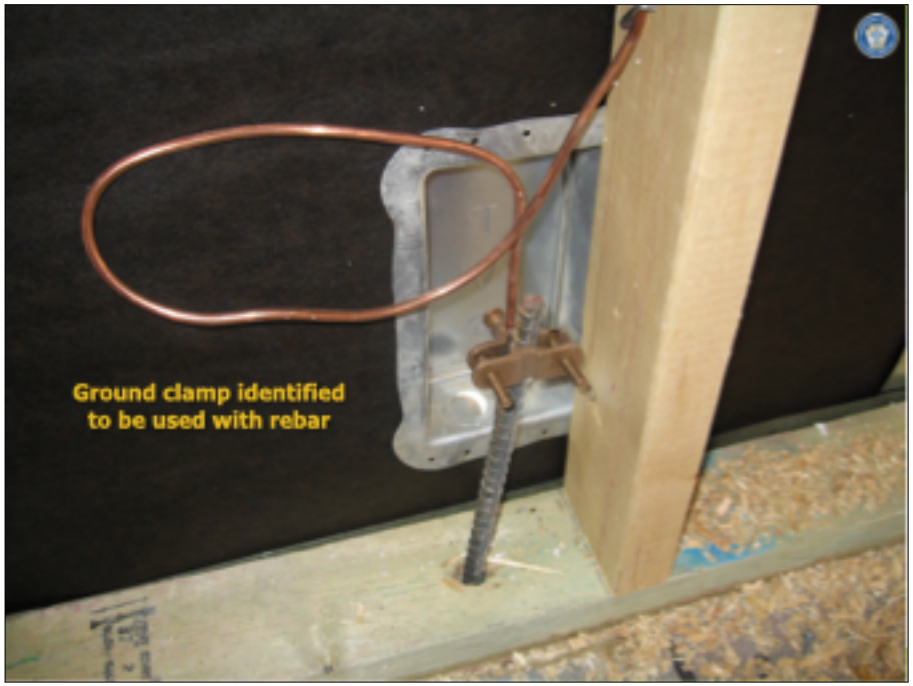
- Common practice to extend a rebar-type concrete-encased electrode out of the footing or foundation before the slab or foundation is poured
- Typically accomplished by using another piece of rebar connected to the concrete-encased electrode and **"stubbed-up"** out of the poured concrete to provide an accessible connection point above the slab
- GEC connection can be made after the foundation has been poured and cured
- Extension or "stub-up" is not part of the concrete-encased electrode
- Permitted by 250.68(C)(3)

Concrete-Encased Electrode Extension

A rebar extension from a concrete-encased electrode is recognized for connection to the grounding electrode

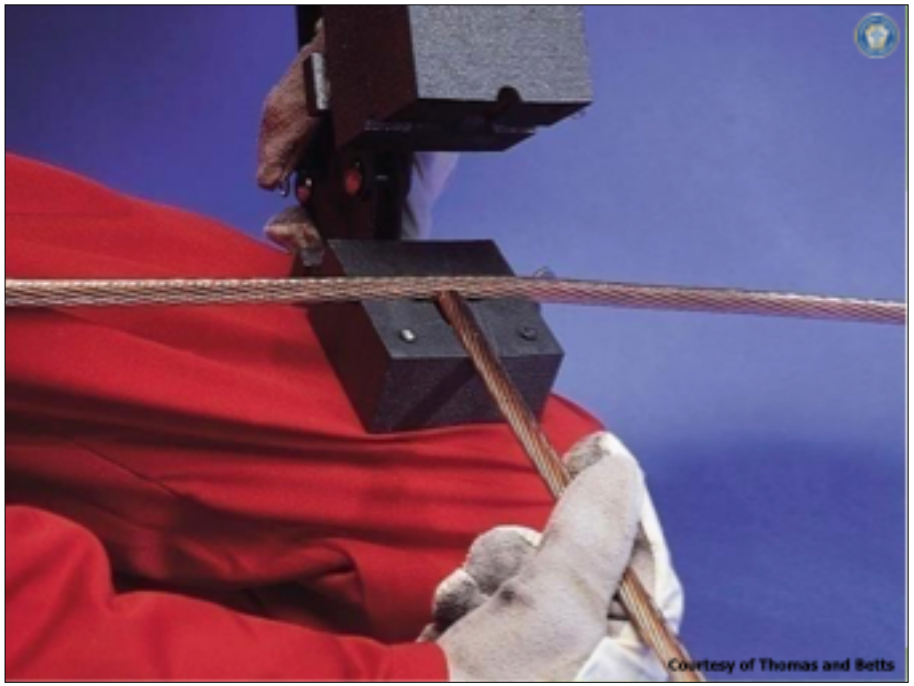


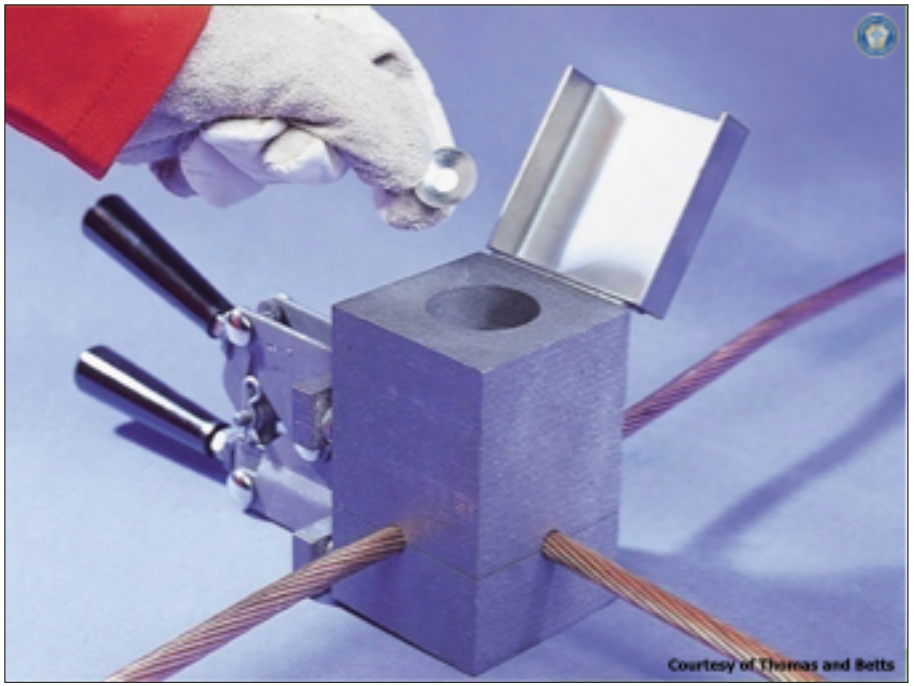
250.68(C)(3)



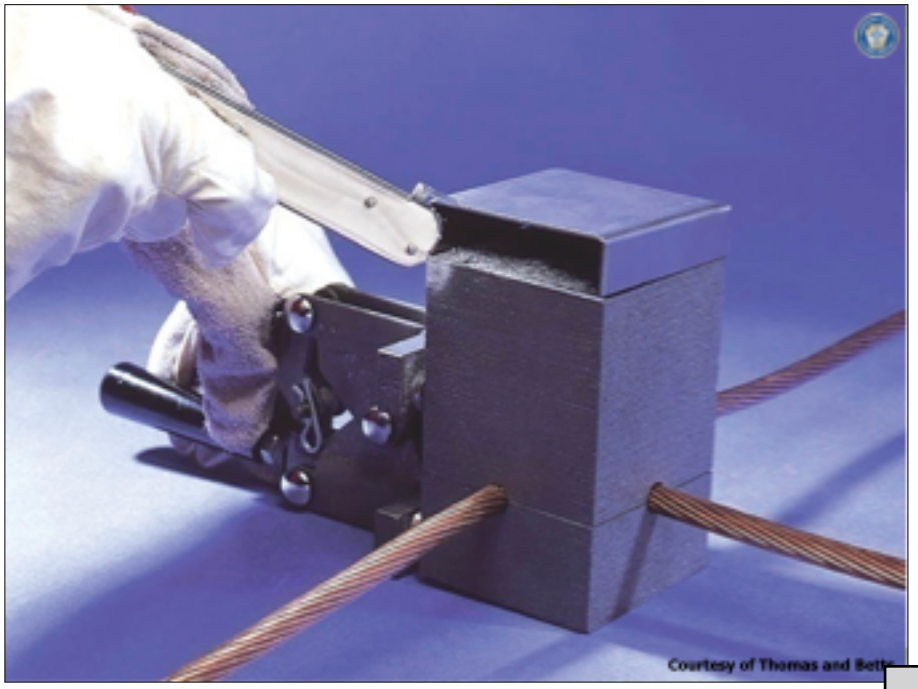
GEC Connections Using Exothermic Welding

- Specific rules for connections of GEC and bonding conductor to grounding electrodes are found at **250.70**
- Connections required to be made by:
  - Exothermic welding
  - Listed lugs
  - Listed pressure connectors
  - Listed clamps
  - Other listed means
- Only connection means not required to be listed are those made by **exothermic welding** *(listed exothermic weld connections are available)*


Courtesy of Thomas and Betts


Courtesy of Thomas and Betts


Courtesy of Thomas and Betts


Courtesy of Thomas and Betts

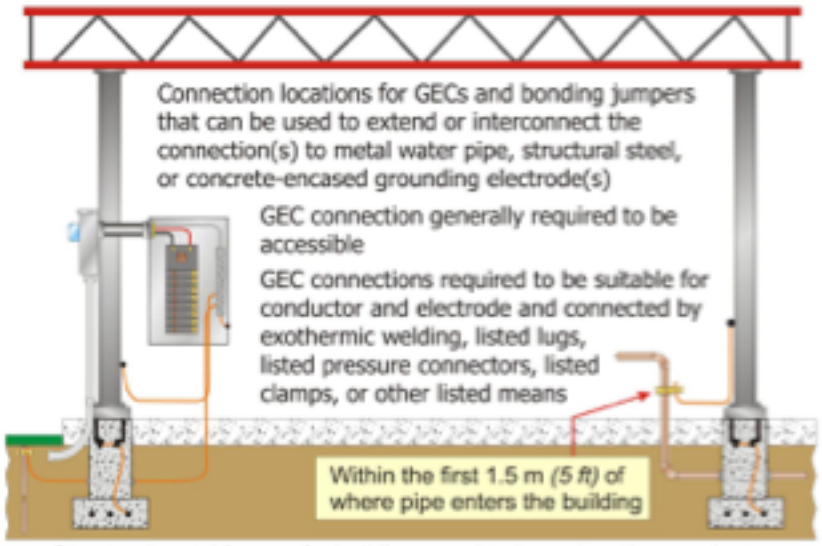
Grounding Electrode Conductor Connections *(cont.)*

- Grounding electrode conductors and bonding jumpers permitted to be connected at the following locations and used to extend the connection to an electrode(s):
  - **Interior metal water piping** located **not more than 1.52 m (5 ft)** from the point of entrance to the building
    - *See 250.68(C)(1)*
  - ***Exception*** *for industrial, commercial, and institutional buildings or structures beyond the first 1.52 m (5 ft) from the point of entrance to the building*
    - *See complete exception for details*

Grounding Electrode Conductor Connections *(cont.)*

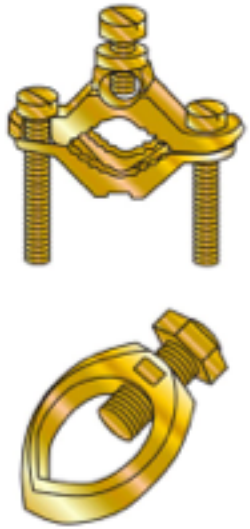
- Grounding electrode conductors and bonding jumpers permitted to be connected at the following locations and used to extend the connection to an electrode(s):
  - The **metal structural frame of a building**
    - *See 250.68(C)(2)*
  - A **concrete-encased electrode** of the rebar-type **extended from its location** within the concrete to an accessible location above the concrete
    - *See 250.68(C)(3)*

250.68 GEC and Bonding Jumpers Connections

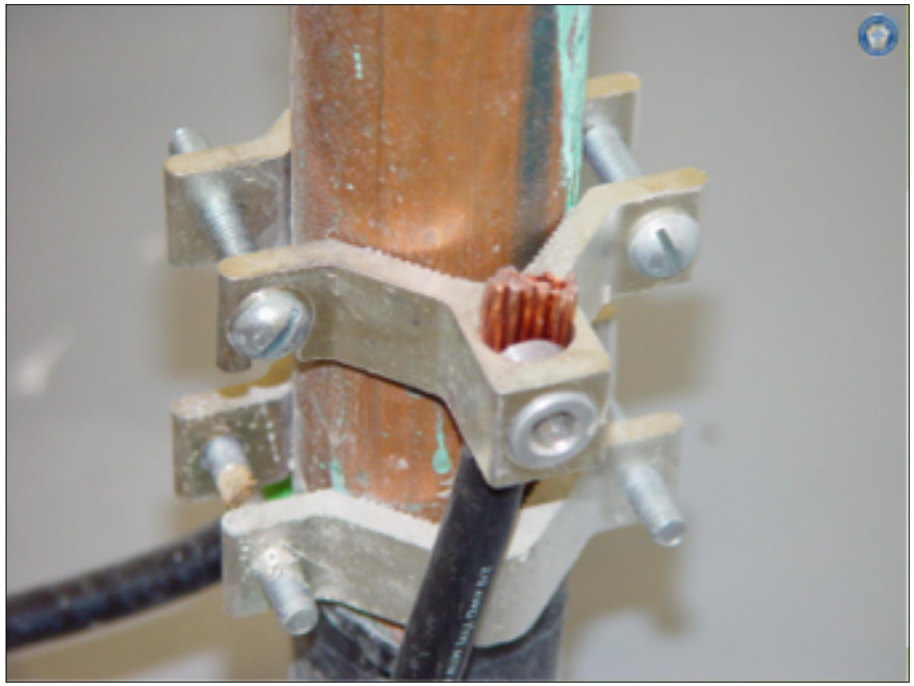


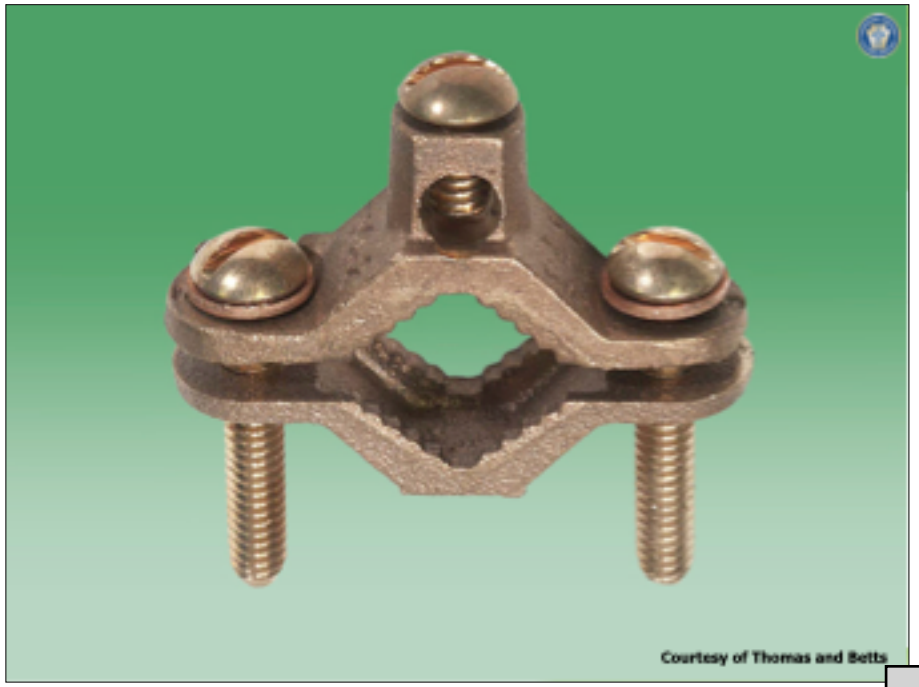
Structural metal frame of a building permitted as a bonding conductor to interconnect electrodes or as GEC

Ground Clamps Listed for Application

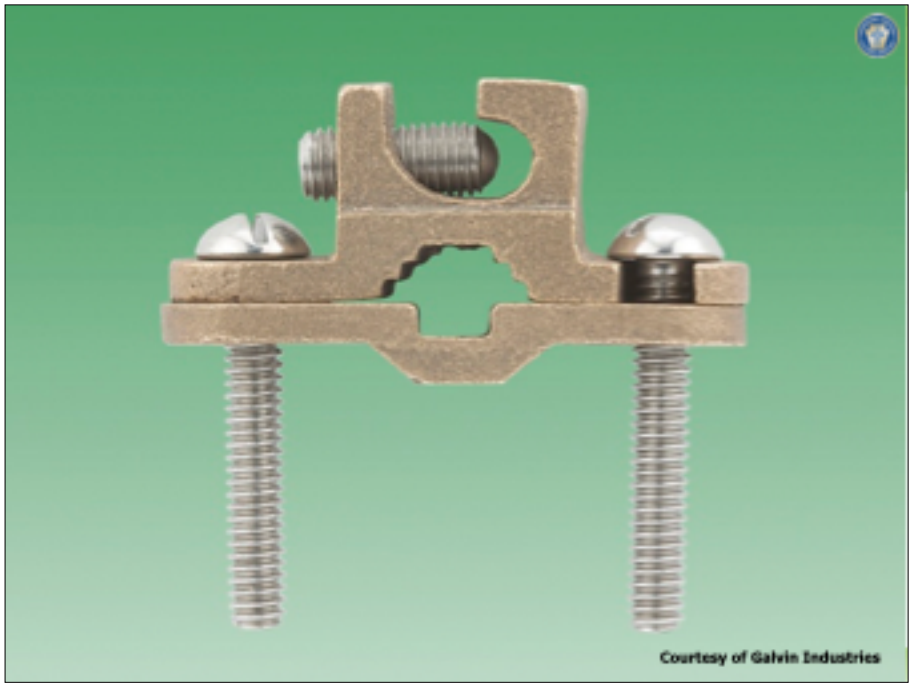


- Grounding electrode conductor connected to grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps or other listed means
- Connection devices shall be listed for materials of the grounding electrode and grounding electrode conductor
- Shall be listed for direct burial where used on pipe, rod or other buried or concrete encased electrodes
- See 250.70





Courtesy of Thomas and Betts



Courtesy of Galvin Industries

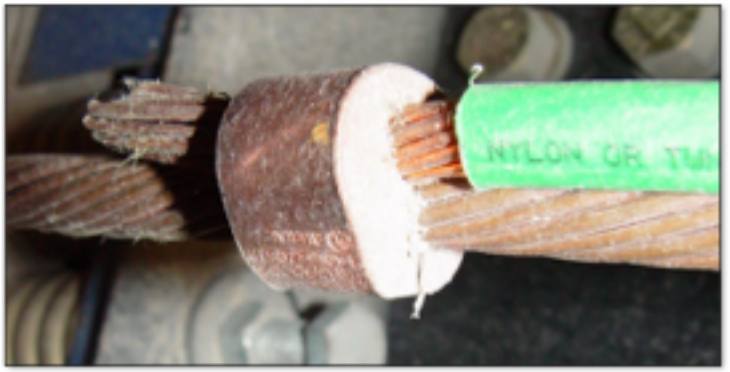
Courtesy of Thomas and Betts

Grounding Electrode Conductor Material

- Copper, aluminum, or copper-clad aluminum *[or the items as permitted in 250.68(C)]*
- Conductors of the wire type shall be:
  - Solid or stranded
  - Insulated, covered, or bare
- Aluminum and copper-clad aluminum grounding electrode conductors are not permitted to be terminated within 450 mm (18 in.) of the earth
- See 250.62 and 250.64(A)

Grounding Electrode Conductor Material *(cont.)*

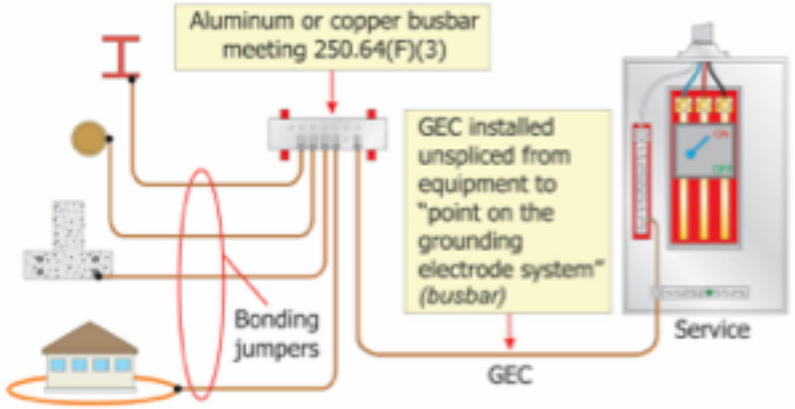
- **No specific color identification** for grounding electrode conductors but 250.119 permits the color **green** to be used for grounding and bonding conductors



Grounding Electrode Conductor Installation

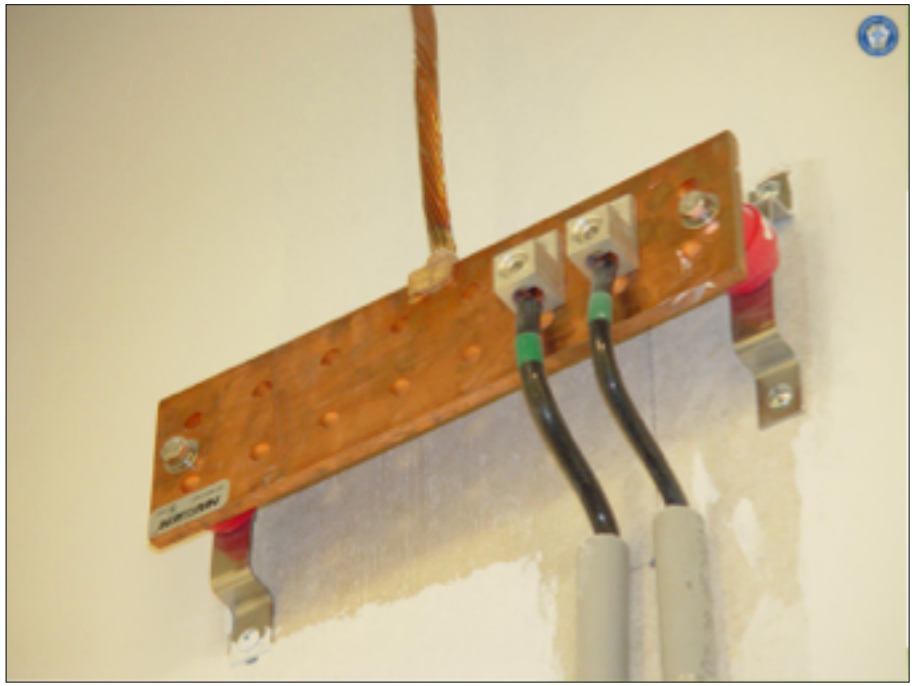
- Where grounding of systems, equipment or both are required, grounding electrode conductors are installed and connected to the grounding electrode system
- *Code* provides **installation requirements** for grounding electrode conductors where installed for services, separately derived systems, or for buildings or structures supplied by a feeder(s) or branch circuit(s)
- See 250.64

250.64(F) Installation to Electrode(s)



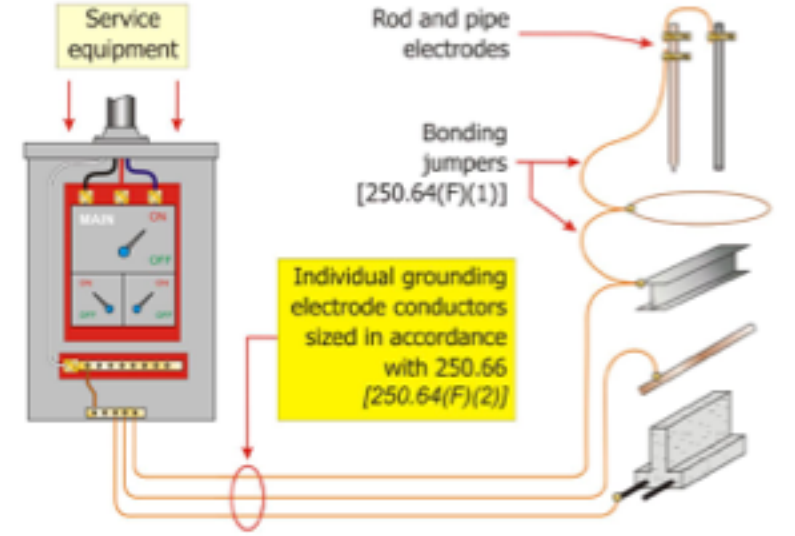
Bonding jumper(s) from grounding electrodes and grounding electrode conductors are permitted to be connected to copper or aluminum busbars to form the grounding electrode system

Connection to be made by a listed connector or by the exothermic welding process



Individual Grounding Electrode Conductor(s)

Individual grounding electrode conductor(s) are permitted to be run to any convenient grounding electrode in the grounding electrode system



GEC - Securing and Protection from Damage

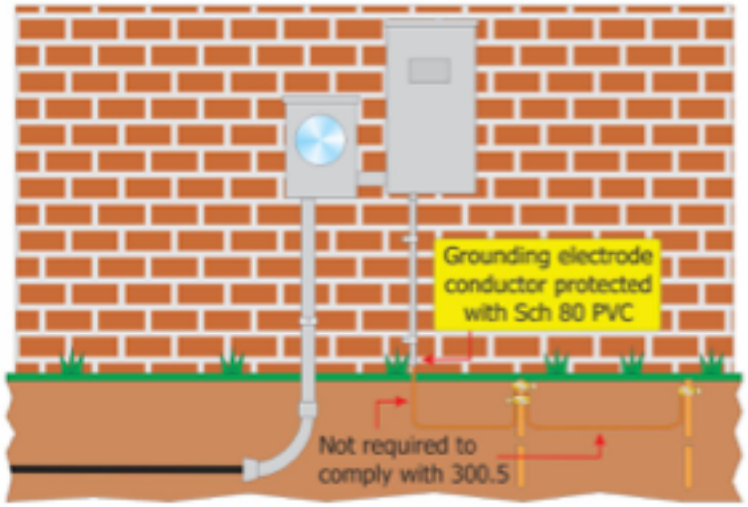
- When exposed, grounding electrode conductor(s) or enclosure(s) are required to be **securely fastened to surface**
- Grounding electrode conductors are permitted to be installed on or through framing members
- Where **not exposed to physical damage**, 6 AWG or larger permitted to run along the surface of the building without protection or metal covering
- Where **exposed to physical damage**, 6 AWG or larger required to be protected by installation in cable armor or raceway *(RMC, IMC, PVC, etc.)*
- Sizes **smaller than 6 AWG** required to be protected from physical damage by installation in cable armor or raceway

GEC - Securing and Protection from Damage *(cont.)*

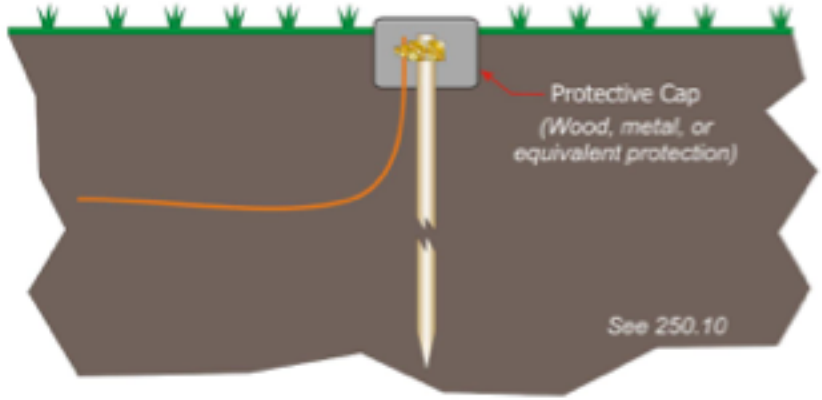
- Grounding electrode conductors and grounding electrode bonding jumpers in contact with the earth are **not required to comply with *300.5*** *(minimum burial depth requirements)*
- Must be buried or otherwise protected if subject to physical damage
- See 250.64(B)(4)

250.64(B)(4) GEC Installation

Grounding electrode conductors and GE bonding jumpers in contact with the earth not required to comply with 300.5, but shall be buried or otherwise protected if subject to physical damage



Protection of Ground Clamp Attachment



Ground clamp to be approved for general use without protection or be protected from physical damage as follows:

- (1) installed where they are not likely to be damaged or
- (2) enclosed in metal, wood, or equivalent protective covering

Splicing Grounding Electrode Conductors

- Grounding electrode conductors generally required to be installed in **one continuous length without a splice** or joint
- If necessary, splices or connections shall be made as permitted in (1) through (4):

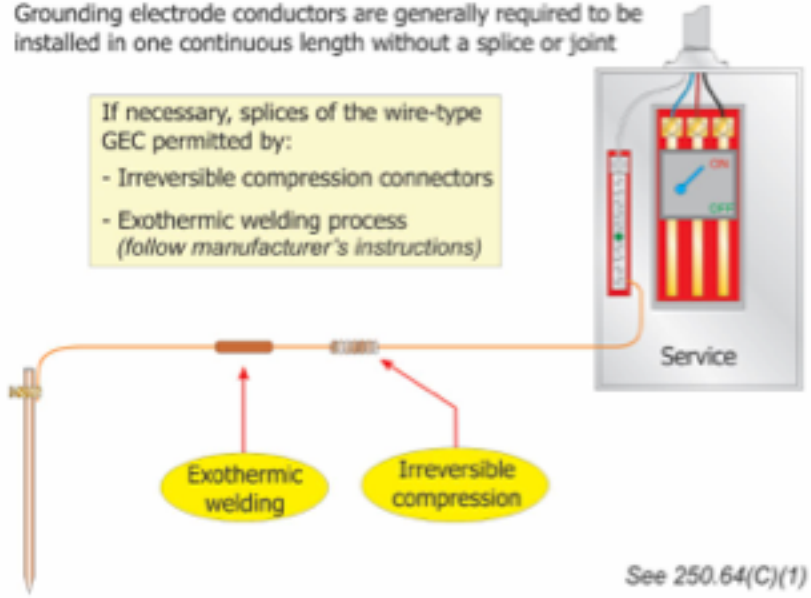
  (1) Splicing of the wire-type GEC permitted only by **irreversible compression-type connectors** listed as grounding and bonding equipment or by the **exothermic welding process**

Splicing Grounding Electrode Conductors

Grounding electrode conductors are generally required to be installed in one continuous length without a splice or joint

If necessary, splices of the wire-type GEC permitted by:

- Irreversible compression connectors
- Exothermic welding process *(follow manufacturer's instructions)*



See 250.64(C)(1)

Splicing Grounding Electrode Conductors (cont.)

- Grounding electrode conductors generally required to be installed in **one continuous length without a splice** or joint
- If necessary, splices or connections shall be made as permitted in (1) through (4):

  (2) Sections of **busbars** shall be permitted to be connected together to form a grounding electrode conductor

Splicing Grounding Electrode Conductors (cont.)

- Grounding electrode conductors generally required to be installed in **one continuous length without a splice** or joint
- If necessary, splices or connections shall be made as permitted in (1) through (4):

  (3) Bolted, riveted, or welded connections of **structural metal frames of buildings** or structures

  (4) Threaded, welded, brazed, soldered or bolted-flange connections of **metal water piping**

Protection from Magnetic Field

- Where **ferrous metal raceways** or enclosures are provided for **protection of the grounding electrode conductor**, special procedures must be followed
- Ferrous metal conduits must be **bonded at both ends** of the grounding electrode conductor to form a **parallel circuit** with the grounding electrode conductor
- Lack of observation, results in **doubling the impedance** of the grounding electrode conductor
- Where the impedance increased, the effectiveness of the grounding electrode conductor is reduced
- See 250.64(E)

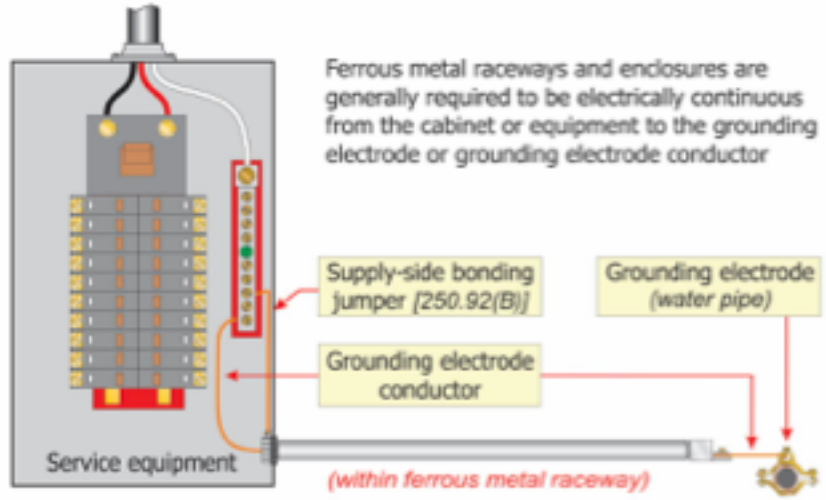
Protection from Magnetic Field *(cont.)*

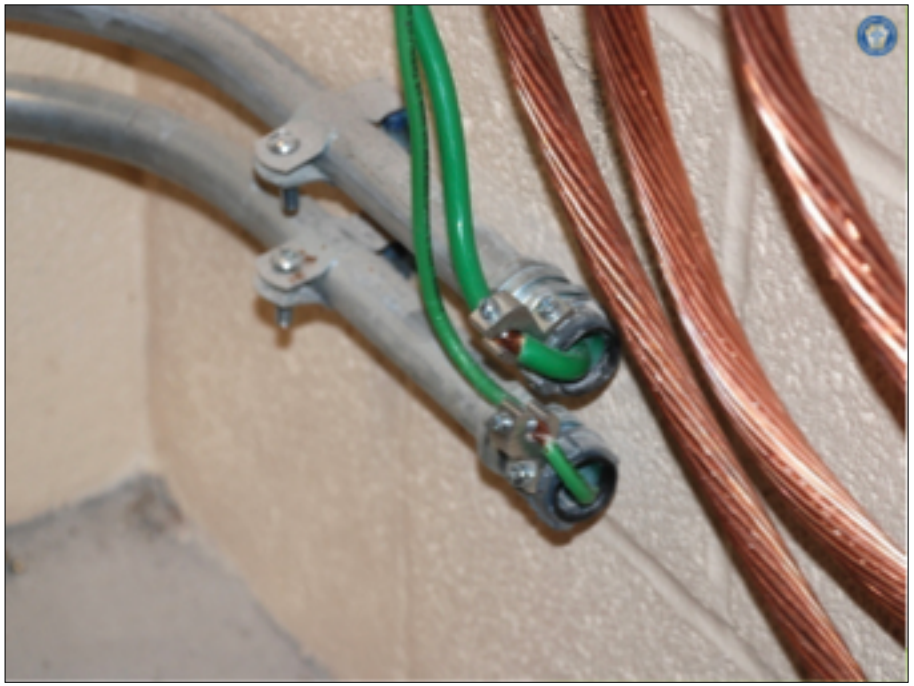
- Ferrous metal conduit must be **electrically continuous** from the point of attachment at the cabinet or equipment to the grounding electrode
- Ferrous metal conduit is required to be **securely fastened** to clamp or fitting
- Nonferrous metal enclosures *(PVC)* are not required to be electrically continuous

Protection from Magnetic Field *(cont.)*

- Ferrous metal conduit not physically continuous from the cabinet or equipment to the grounding electrode is required to be made electrically continuous by **bonding each end of the conduit** to the grounding electrode conductor
- This bonding is required at each end and to all intervening ferrous metal raceways, boxes, and enclosures between the service equipment and the grounding electrode

Protection from Magnetic Field





Protection from Magnetic field

Bonding required at grounding electrode conductor to both ends of ferrous metal raceways and enclosures that are not electrically continuous from cabinet or enclosure to grounding electrode or grounding electrode conductor

Note: Bonding jumper is required to be the same size as the grounding electrode conductor

Ferrous metal raceway or enclosure

(example: RMC or EMT raceways)

Nonferrous metal raceway or enclosure

(example: Aluminum raceways)

Nonmetallic raceway of enclosure

(example: PVC raceways)

Grounding Electrode Conductor Connections

Grounding electrode conductor enclosed in armor cable and bonded to clamp and grounding electrode *(must be protected from magnetic field)*

Grounding and ElectroMagnetic Interference (GEMI) Research

Steel Tube Institute OF NORTH AMERICA

www.steeltubeinstitute.org

Division of Current in Both Paths (Conductor vs Raceway)

Conductor	Conduit Size	Total Amperes	Current in Conductor	Current on Conduit
6	½	100	3	97
6	½	300	5	295
2	¾	90	7	83
2	¾	350	10	340
2/0	1	150	15	135
2/0	1	590	5	585
4/0	1¼	225	15	210
4/0	1¼	885	15	870

The above test data confirms that, for all practical purposes, the impedance of a conductor enclosed in steel conduit *(when the conduit is bonded at both ends)* is approximately equal to the impedance of the conduit

**Data from Grounding ElectroMagnetic Interference (GEMI) analysis software*

Design Considerations for Grounding Electrode Conductor Length

- Short-time rating of copper grounding electrode conductor related to I^2t rating *(current x current x time)*
- Five-second rating is approximately 1 ampere for every 42.25 circular mil conductor area
- Voltage drop for grounding electrode conductors over 30 m (100 ft) should not exceed 40 volts
- The *NEC* does not currently limit the length or require larger grounding electrode conductors for long runs, but it should be a design consideration

Design Considerations for Grounding Electrode Conductor Length

- **Example:** 1/0 AWG copper service-entrance conductors, GEC is 6 AWG copper *(Table 250.66)*, length is 45 m (150 ft)
- 6 AWG has 26,240 circular mils, resulting in a short-time rating of 621 amperes, and a dc resistance of 0.0737 ohms for 45 m (150 ft.) (0.491 ohms/k ft.)
- Voltage drop would be 621 x 0.0737 or 46 volts
- Voltage drop for GECs over 30 m (100 ft) should not exceed 40 volts
- Next larger-sized GEC (4 AWG) has resistance of 0.0462 ohms for 45 m (150 ft) (0.308 ohms/k ft.)
- Voltage drop would be 621 x 0.0462 or 28.7 volts
- 4 AWG copper GEC is the proper size

Grounding Electrode Conductors for Direct-Current Circuits

- For direct-current **(dc) circuits**, size of the grounding electrode conductor is specified in **250.166**
- Size can be larger than would be required for the same size alternating-current (ac) circuit
- **Resistance** only factor in determining current in a dc circuit
- Grounding electrode conductor for dc systems does not have to be larger than **3/0 copper** or **250 kcmil aluminum**

Chapter Eight:
Bonding Enclosures and Equipment

- The purpose of bonding
- Requirements for maintaining continuity and conductivity
- Bonding of systems over 250 volts to ground
- Bonding multiple raceway systems
- Bonding of grounding-type receptacles
- Bonding of metal water piping systems
- Bonding of other metal piping systems
- Bonding of interconnected exposed structural metal framing

Bonding Enclosures and Equipment

- Bonding is an **ongoing process** in any electrical system from the point of service delivery to final outlet on the system
- Bonding metal parts or enclosures of electrical components and conductors **connects them together** electrically and mechanically, establishing **electrical continuity and conductivity**
- Bonding has a very important function electrically for both grounded and ungrounded systems
- Bonding metallic parts together puts parts at the **same potential**
- Bonding connection to the grounding electrode at the service or source of separately derived system puts parts at the **ground (earth) potential**

Definitions

- ***Bonded (Bonding):*** "Connected to establish electrical continuity and conductivity."
- ***Bonding Conductor or Jumper:*** "A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected."
- ***Bonding Jumper, Equipment:*** "The connection between two or more portions of the equipment grounding conductor."
- ***Bonding Jumper, Main:*** "The connection between the grounded circuit conductor and the equipment grounding conductor at the service."

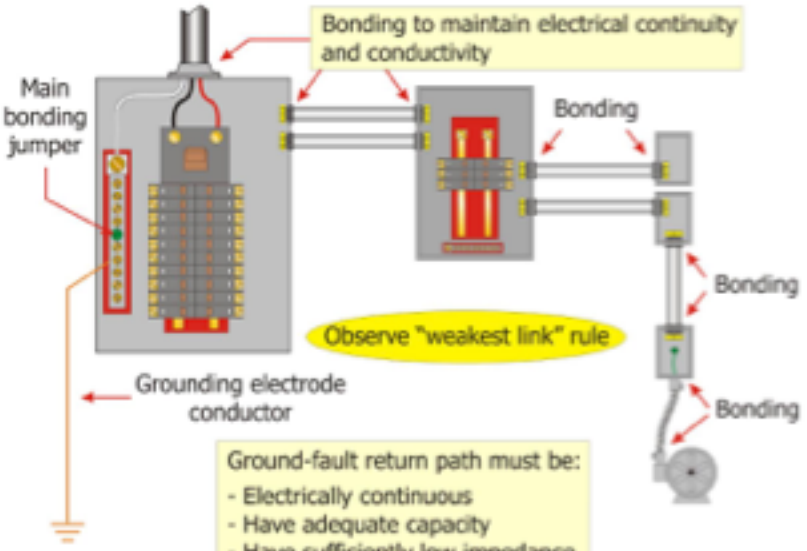
Maintaining Continuity

- Effective bonding is necessary to assure electrical continuity and capacity to safely conduct any fault current likely to be imposed
- Any nonconductive paint, enamel, or similar coating to be removed at threads, contact points, and contact surfaces or have equipment connected by means of fittings designed so as to make such removal unnecessary
- See 250.96(A)

Maintaining Continuity *(cont.)*

- "**Weakest link**" rule applies to the ground-fault return path
- To provide adequate safety, the effective ground-fault current path is required to:
  - Be **electrically continuous**
  - Have **adequate capacity** to conduct safely any fault current likely to be imposed on it
  - Have sufficiently **low impedance** to limit the voltage to ground and to facilitate the operation of the circuit-protective devices
- See 250.4(A)(5) and 250.4(B)(4)

Observe the "Weakest Link" Concept



Clean Surfaces

- Nonconductive coatings such as paint, lacquer and enamel must be removed from threads and other contact surfaces of equipment to be grounded, unless…
- Connected by means of fittings designed to make such removal unnecessary
- Nonconductive coatings could restrict equipment grounding and impair ground-fault return path
- See 250.96(A) and 250.12

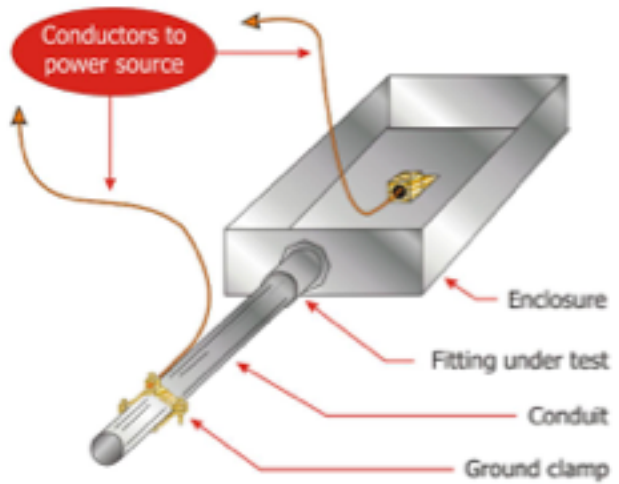
Testing of Conduit Fittings

- The importance of removing paint from enclosures where the conduit or raceway is intended to serve as the fault-current path is further emphasized in a report titled "***Conduit Fitting Ground-Fault Current Withstand Capability***," issued by Underwriters Laboratories on June 1, 1992
- The following slides illustrate the testing performed by UL on various conduit and tubing fittings to determine suitability during ground-fault conditions

Testing of Conduit Fittings *(cont.)*

- Over 300 conduit-fitting assemblies from ten different manufacturers were subjected to a current test to simulate performance under ground-fault conditions
- A sample assembly consisted of a conduit fitting secured to one end of a two-foot length of conduit and attached to a metal enclosure
- Some of the enclosures were bare metal or galvanized, and others were painted with enamel coating typical of construction of enclosures in the 1990s
- Seven of the more than 300 assemblies tested sustained damage
- A visual examination of sample assemblies that failed showed that melting of the die-cast zinc locknuts occurred as a result of the fault current

Conduit and Tubing Fitting Test Model



"Conduit Fitting Ground-Fault Current Withstand Capability" issued by Underwriters Laboratories on June 1, 1992

Conduit and Tubing Fitting Test Model

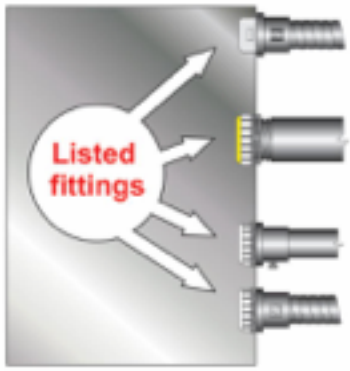
"Conduit Fitting Ground-Fault Current Withstand Capability" issued by Underwriters Laboratories on June 1, 1992

Conclusions on Fittings Testing

- 1. Over 300 conduit fitting assemblies from 10 manufacturers were tested…seven assemblies failed
- 2. Failures probably due to high resistance between fitting and enclosure as fitting locknut did not penetrate the paint
- 3. Some fittings that did not fail showed signs of arcing and welding
- 4. Most fitting temperatures matched conduit temperatures
- 5. Flexible metal conduit temperature was much higher than the temperature of the fittings
- 6. Fittings providing good electrical contact to both conduit and enclosure will provide **suitable path for fault current**

Bonding for Circuits Over 250 Volts

For circuits exceeding 250 volts to ground, the electrical continuity of metal raceways and metal-sheathed cables that are not used for service-conductors must also be ensured by specific methods such as:



See 250.97

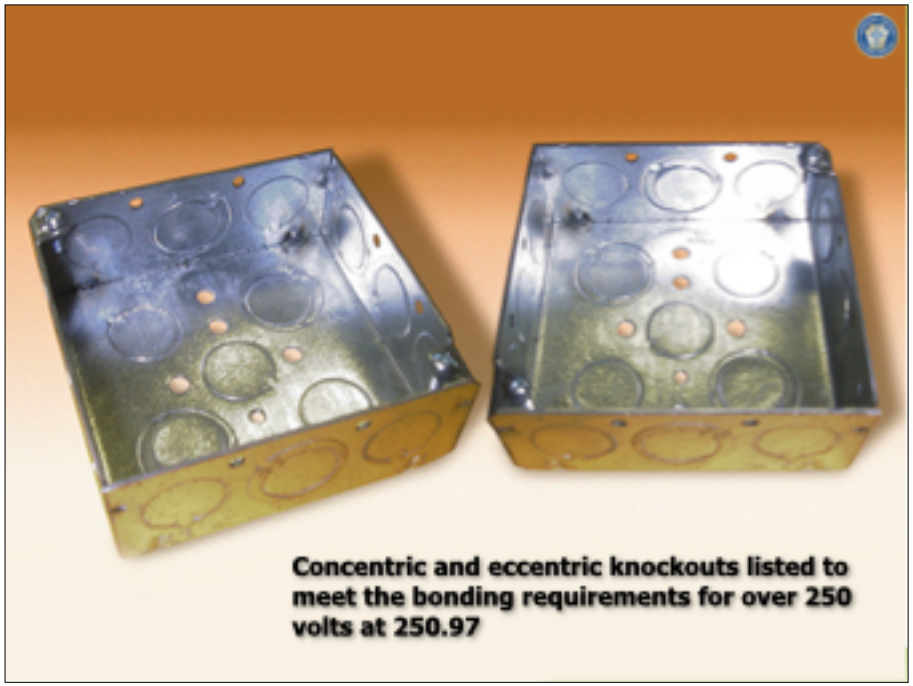
- Threadless couplings and connectors for cables with metal sheaths
- Two locknuts, on rigid metal conduit or IMC, one inside and one outside
- Fittings with shoulders that seat firmly against the box or enclosure such as for EMT, flexible metal conduit and cable connectors with one locknut inside
- Listed fittings

Also permitted:

- Threaded couplings and hubs
- Threadless couplings and connectors
- Bonding jumpers
- Bonding locknuts, bushings, and wedges

Bonding for Over 250 Volts

- All listed device outlet boxes are specially designed and tested so knockouts perform satisfactorily for over 250-volt-to-ground applications
- Also, see UL ProductSpec for the guide card information under category code QCIT for listing details on these device boxes



Concentric and eccentric knockouts listed to meet the bonding requirements for over 250 volts at 250.97

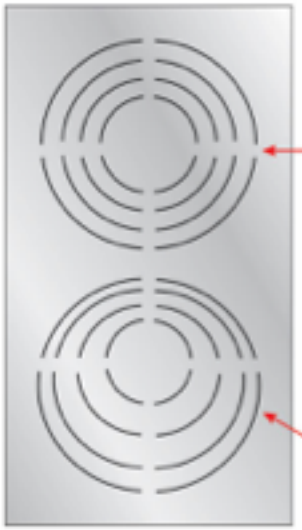
Concentric or Eccentric Knockouts

- Caution needs to be exercised in the use of equipment that has concentric or eccentric knockouts
- Ability to carry fault current must be of concern
- Common to find nibs of adjacent rings damaged during removal of the desired knockout
- Leaves less material available for carrying fault current
- Safest practice is to install bonding bushings around concentric and eccentric knockouts where there is any question about their integrity

Concentric or Eccentric Knockouts *(cont.)*

- Concentric and eccentric knockouts in equipment *(such as cabinets, enclosed switches, junction and pull boxes, auxiliary gutters and wireways)* **not tested or certified** by an electrical products testing laboratory for their current-carrying ability
- Specific methods provided for in **250.97** must be used if those enclosures have eccentric or concentric knockouts

Concentric and Eccentric Knockouts



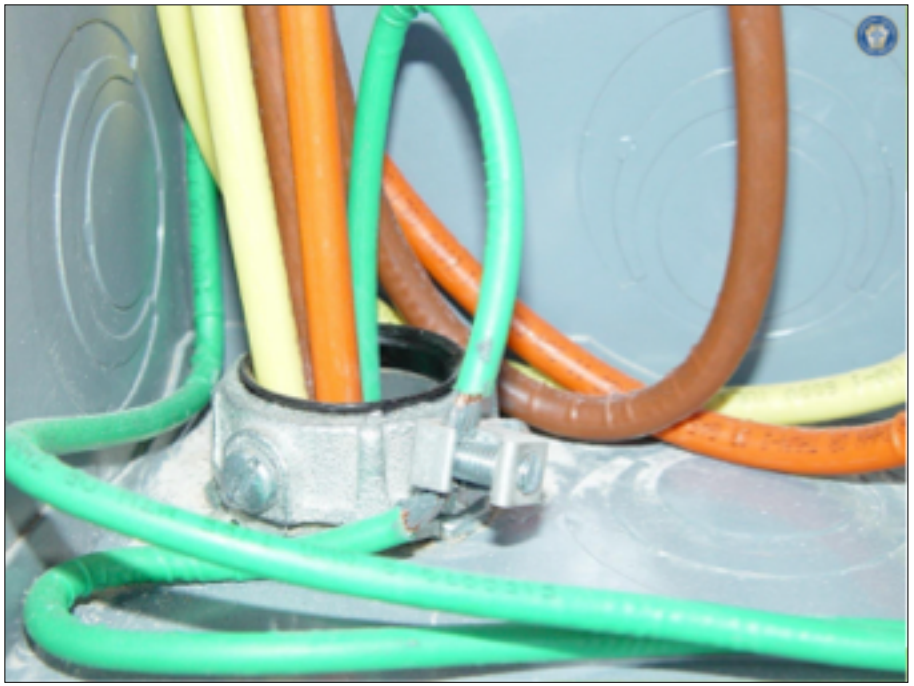
Concentric knockouts

It may be necessary to bond around concentric knockouts at enclosures such as disconnects and panelboards to ensure current-carrying capacity

Bonding jumpers required around impaired connections such as reducing washers, concentric or eccentric knockouts

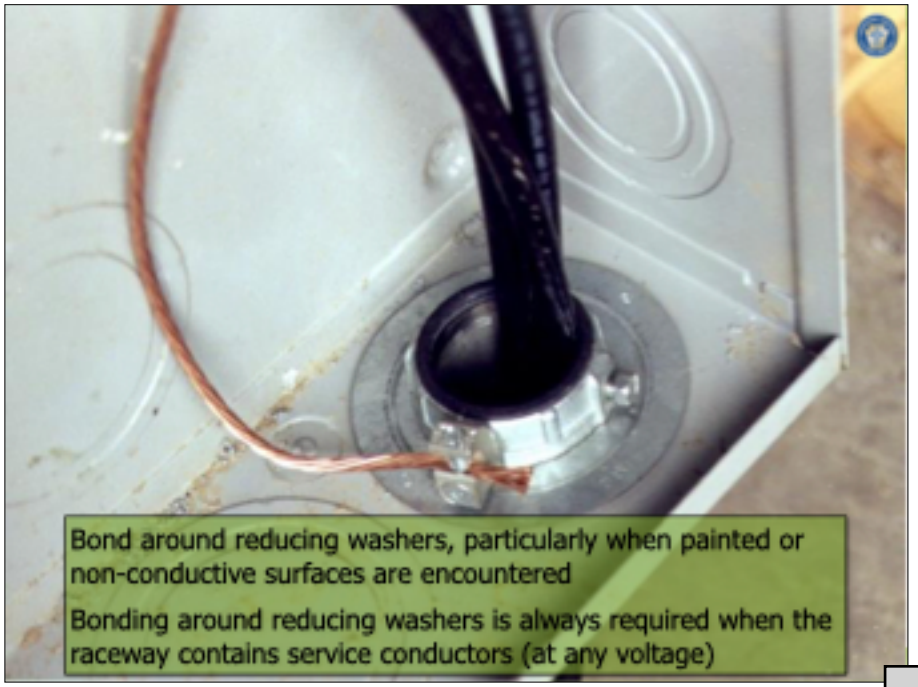
Eccentric knockouts

Eccentric rings present the same obstacle to carrying fault current as do concentric knockouts



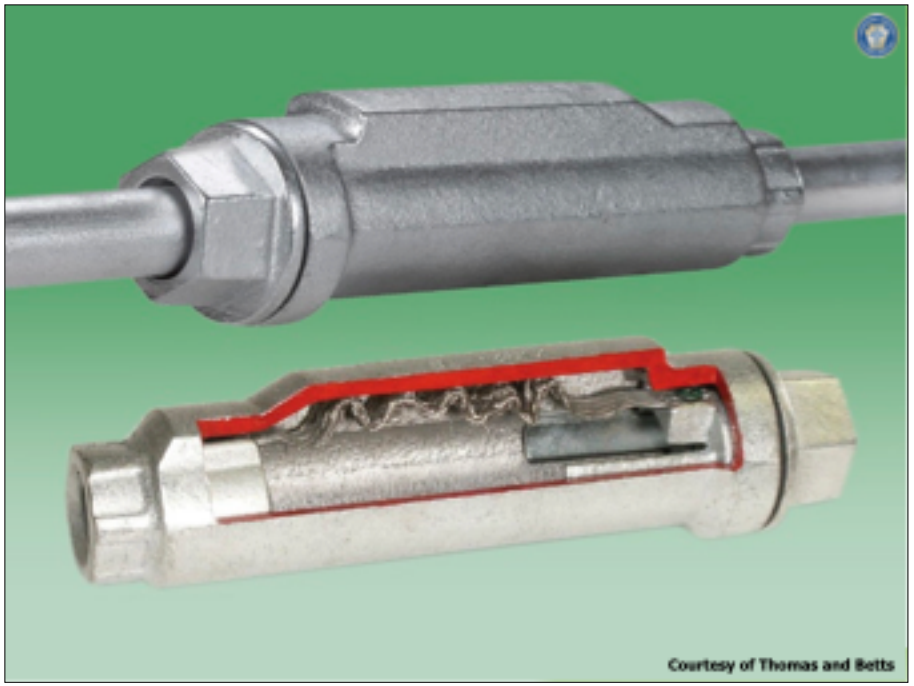
Reducing Washers

- Reducing washers are evaluated and listed for bonding over and under 250 volts for other than raceways used for service conductors *(see UL ProductSpec, category QCRV)*
- Bonding around reducer washers at raceways containing service conductors is required by 250.92(B)
- Where painted or coated enclosures are encountered and the paint or coating under the washer is not removed, one should always bond around to provide an adequate fault-return path
- Use reducing washers only where all the rings of concentric or eccentric knockouts are removed



Bonding Loosely Jointed Metal Raceways

- Expansion fittings and telescoping sections of metal raceways are required be made **electrically continuous** by equipment bonding jumpers or other means
- Bonding is required around these types of fittings unless the fitting is listed for providing bonding around the expansion feature of the fitting
- See 250.98



Courtesy of Thomas and Betts

Attaching Bonding Jumpers

- Good electrical contact must be maintained
- Where used between grounding electrodes or around water meters and similar equipment, good electrical contact must be maintained
- The arrangement of bonding jumpers must be such that the disconnection or removal of equipment will not interfere with or interrupt the grounding and bonding continuity of the jumper
- See 250.68(B)

Attaching Bonding Jumpers *(cont.)*

- Bonding jumper and equipment grounding conductor connections are required to be made using one or more of the following methods:
  - (1) Listed pressure connectors
  - (2) Terminal bars
  - (3) Pressure connectors listed as grounding and bonding equipment
  - (4) Exothermic welding process
  - (5) Machine screw-type fasteners that engage not less than two threads or are secured with a nut

Attaching Bonding Jumpers *(cont.)*

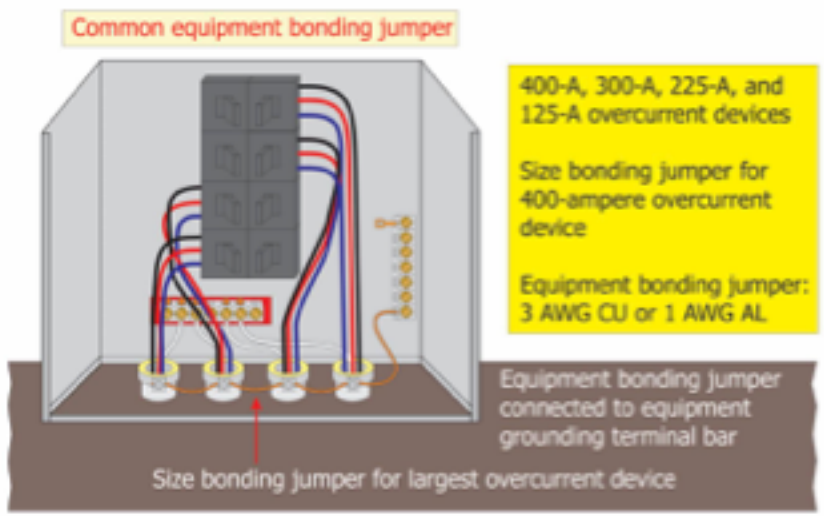
- Bonding jumper and equipment grounding conductor connections are required to be made using one or more of the following methods:
  - (6) Thread-forming machine screws that engage not less than two threads in the enclosure
  - (7) Connections that are part of a listed assembly
  - (8) Other listed means
- Connection that depends on solder is not acceptable
- See 250.8

Bonding Multiple Raceway Systems *(Load Side)*

- Permitted to use **single equipment bonding jumper** to bond one or **several raceways**
- Size single equipment bonding jumper based on largest overcurrent device ahead of conductors in raceways
- Also permitted to connect **individual equipment bonding jumpers** to **each raceway** individually
- Size individual bonding jumpers in accordance with 250.122 and the individual overcurrent devices
- See 250.102(D)

Bonding Multiple Raceways *(Load Side)*

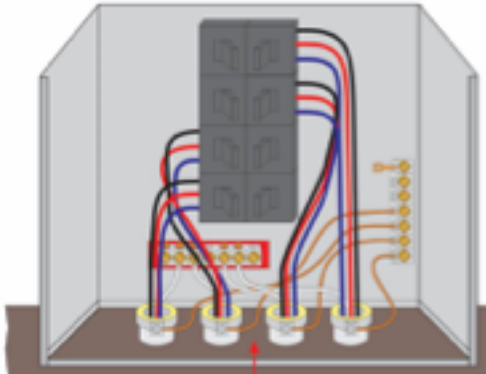
Open-bottom switchboard or motor control center



Bonding Multiple Raceways *(Load Side)*

Open-bottom switchboard or motor control center

Individual equipment bonding jumper(s)



	CU	AL
400 A	= 3 AWG,	1 AWG
300 A	= 4 AWG,	2 AWG
225 A	= 4 AWG,	2 AWG
125 A	= 6 AWG,	4 AWG

Equipment bonding jumper connected to equipment grounding terminal bar

Size bonding jumper(s) for individual overcurrent devices

Bonding of Grounding-Type Receptacles

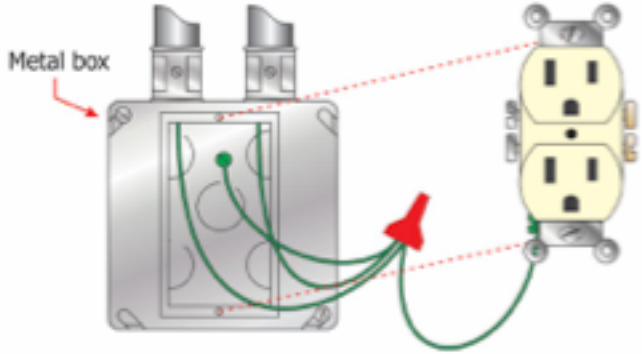
- An equipment bonding jumper is required to be used to connect the grounding terminal of a grounding-type receptacle to a grounded box unless grounded as in 250.146(A) through (D):
  - (A) Surface-mounted boxes
  - (B) Contact devices or yokes
  - (C) Floor boxes
  - (D) Isolated ground receptacles
- Size equipment bonding jumper in accordance with Table 250.122 based on the rating of the overcurrent device protecting the circuit conductors
- See 250.146

Continuity and Attachment of EGC to Boxes

- **All equipment grounding conductors** associated with any and all circuits in the box must be connected together and to the box *(not just EGCs of each associated circuit)*
- Exception gives relief to EGCs of an **isolated ground circuit** *(isolated ground receptacle not required to be connected to the other EGCs or to the box)*
- Reference **250.8** *(Connection of Grounding and Bonding Equipment)* for guidance on terminating an EGC or bonding jumper to a metal box or enclosure
- See 250.148

Bonding of Grounding-Type Receptacles

Splice or join all equipment grounding conductors and bonding jumpers together inside box using suitable devices



Connect bonding jumper to grounding terminal of grounding receptacle unless:

(A) Boxes mounted on surface *(Metal-to-metal contact)*

(B) Contact devices listed as self-grounding type

(C) Floor boxes listed for grounding

(D) Isolated equipment grounding terminal

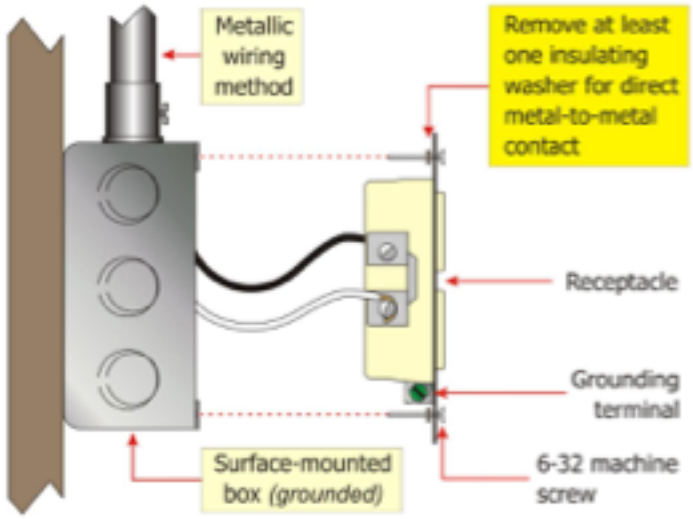
See 250.146 and 250.148

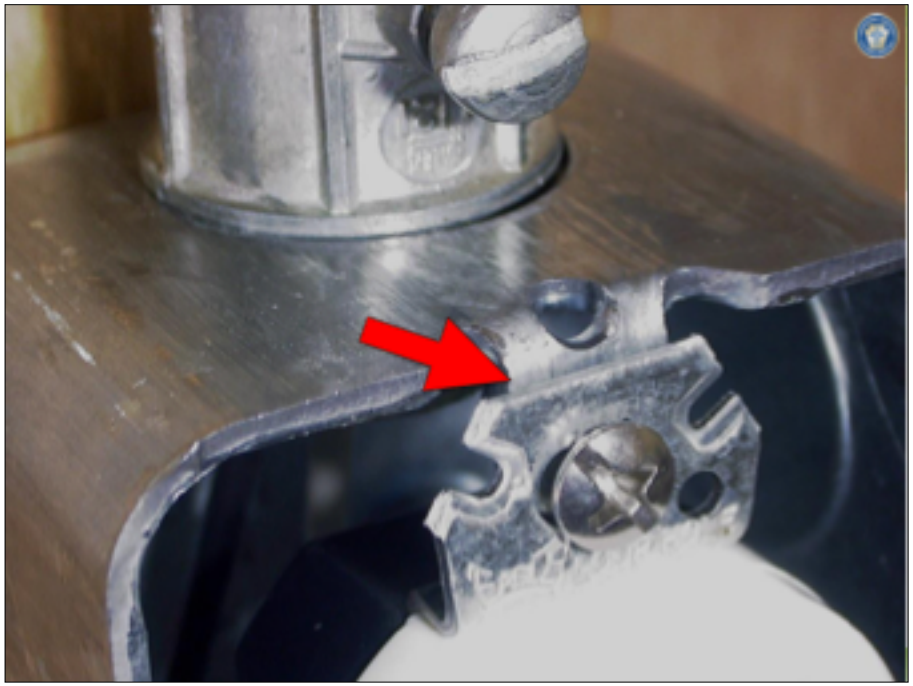
Bonding of Grounding-Type Receptacles *(cont.)*

- Surface-Mounted Boxes [250.146(A)]
  - Mounted on surface only
  - Direct metal-to-metal contact
  - Box permitted to ground receptacle
  - At least one insulating washer *(holding screws)* is required to be removed from the receptacle
  - Raised-cover mounted receptacles permitted for grounding and bonding of receptacle

250.146(A) Surface-Mounted Box

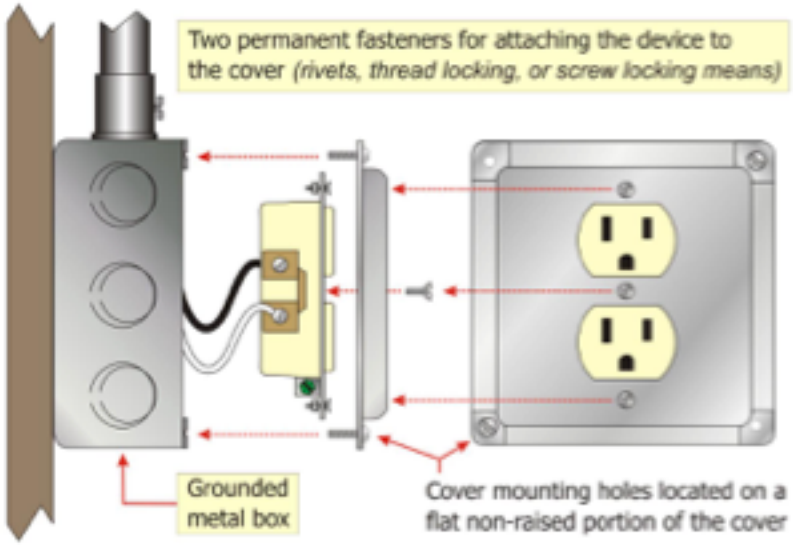
Direct metal-to-metal contact from metal mounting yoke to surface-mounted metal box permitted for grounding of receptacle





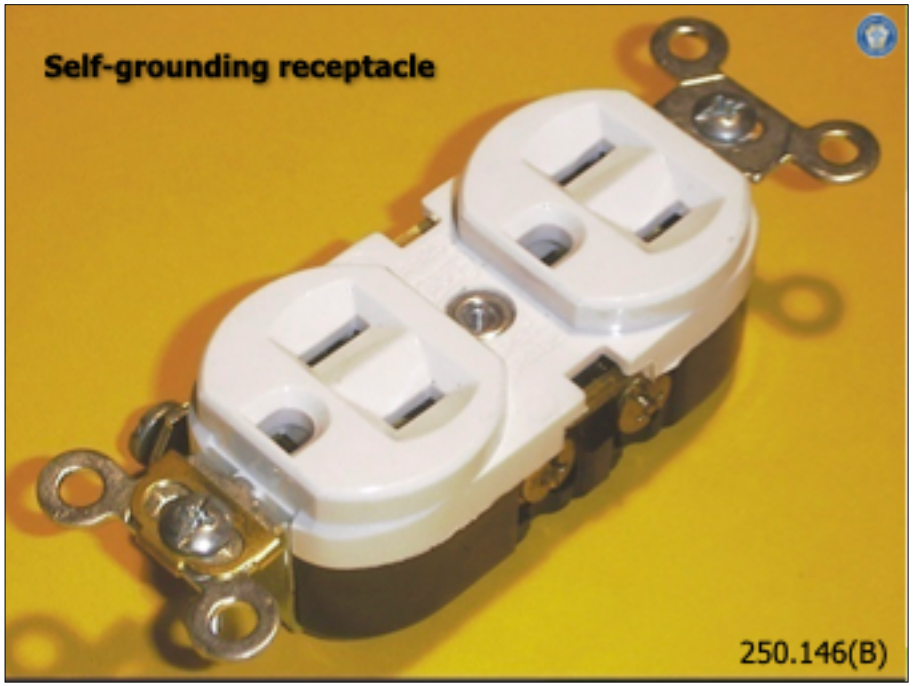
250.146(A) Surface-Mounted Box

Listed exposed work cover is permitted as the grounding and bonding means



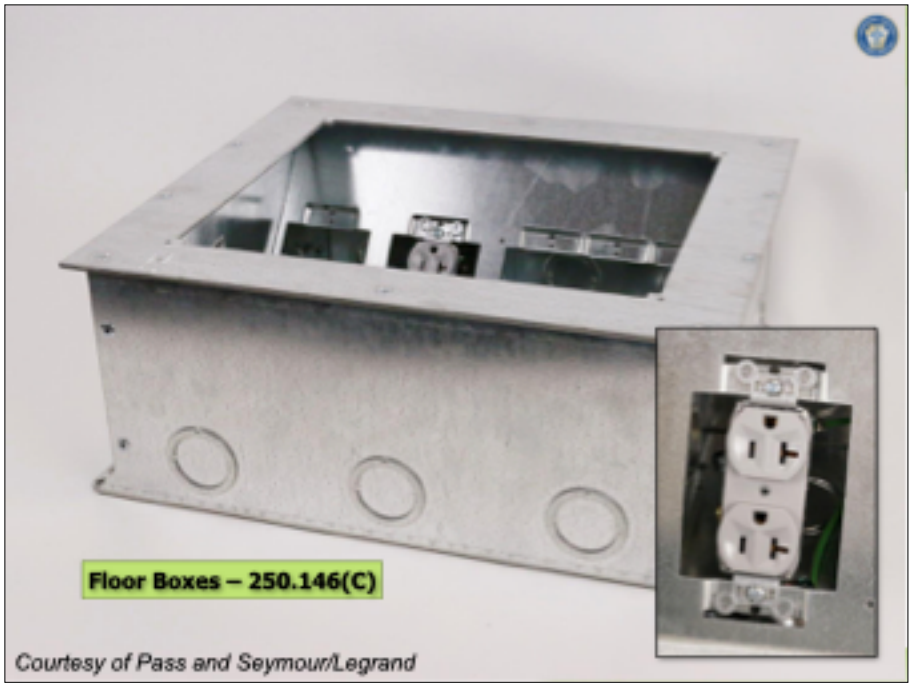
Bonding of Grounding-Type Receptacles *(cont.)*

- Contact Devices or Yokes [250.146(B)]
  - Contact devices or yokes designed and listed as **self-grounding** are permitted in conjunction with the supporting screws to establish the equipment bonding means between the receptacle device yoke and flush-type boxes
  - The use of a self-grounding receptacle is not permitted to be the means to ground the metal box *[see 250.148(B) and (C)]*



Bonding of Grounding-Type Receptacles *(cont.)*

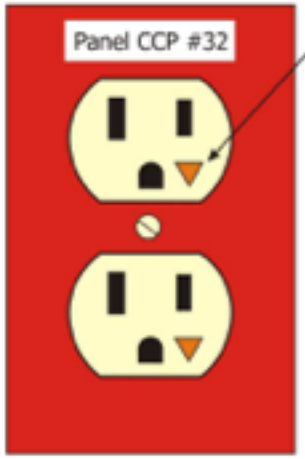
- Floor Boxes [250.146(C)]
  - **Floor boxes** designed for and listed as providing satisfactory ground continuity between the box and the receptacle device are permitted as a grounding/bonding means between the receptacle device yoke and the floor box



Bonding of Grounding-Type Receptacles *(cont.)*

- Isolated Receptacles [250.146(D)]
  - Where installed for the reduction of electrical noise *(electromagnetic interference)* on the grounding circuit, a **isolated ground receptacle** is permitted
  - Grounding terminal is **purposely insulated** from the receptacle mounting means but is connected to an insulated EGC run with the circuit conductors
  - IG EGC permitted to pass through one or more panelboards without a connection to the panelboard grounding terminal bar
  - IG EGC permitted to pass through boxes, wireways, or other enclosures without being connected to enclosures

406.3(D) Isolated Ground Receptacles



- Isolated ground receptacles to be identified by orange triangle on face *[406.3(D)]*
- To be used only with isolated equipment grounding conductors *[406.3(D)(1)]*
- Isolated ground receptacles installed in nonmetallic boxes shall be covered with a nonmetallic faceplate unless the box has a feature or accessory for grounding the faceplate *[406.3(D)2)]*
- Isolated equipment grounding conductor for isolated ground receptacles permitted to pass through panelboards, boxes, wireways, and other enclosures *[250.146(D)]*

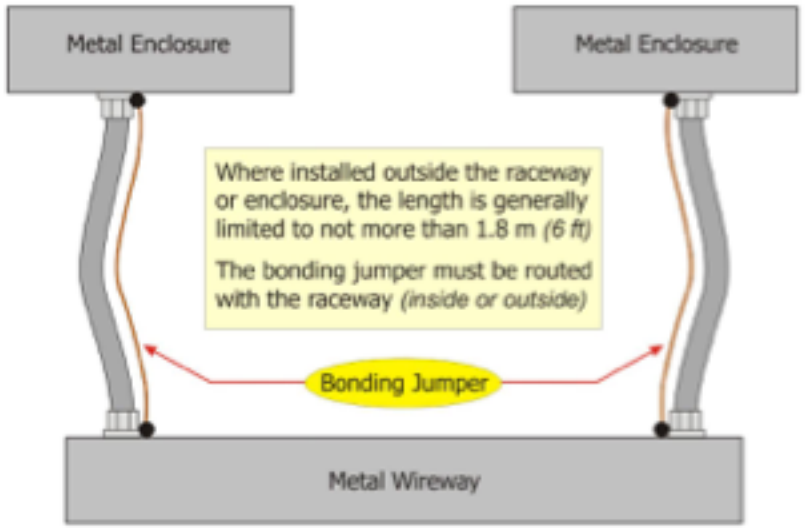
Installation of Bonding Jumpers

- **Equipment bonding jumper** is defined in Article 100 as "The connection between two or more portions of the equipment grounding conductor."
- Definition describes the installation of equipment bonding jumpers on the **load side** of overcurrent protective devices
- On the **line side** *(supply side)*, such as at the service or source of separately derived system, this jumper is a **supply-side bonding jumper** *[see 250.102(C) and 250.30(A)(2)]*

Installation of Bonding Jumpers *(cont.)*

- Bonding jumpers or conductors and equipment bonding jumpers are permitted to be installed **inside or outside** of a raceway or an enclosure
- If installed **inside** a raceway, it must comply with the requirements of 250.119 *(ID of an EGC)* and 250.148 *(Continuity and attachment of EGC to boxes)*
- If installed on the **outside**, the length of conductor shall not exceed 1.8 m (6 ft) and must be routed with the raceway or enclosure *(see exception for outside pole locations)*
- See 250.102(E)

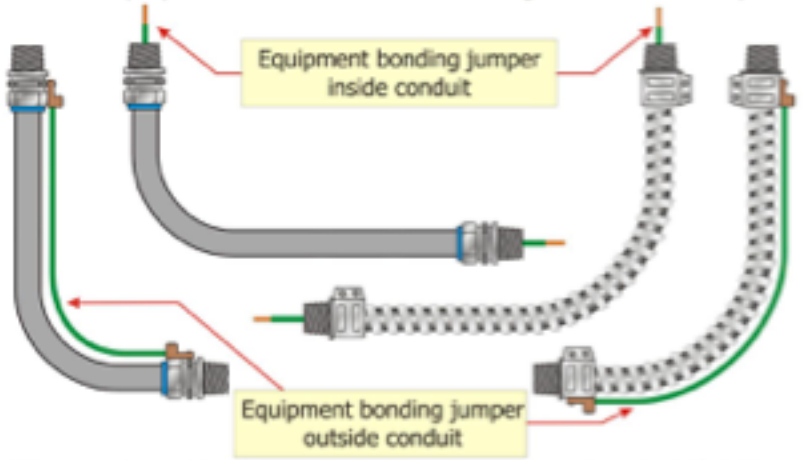
Bonding Jumper Installed Outside of Raceway



See 250.102(D) and (E)

Equipment Bonding Jumper Installation

Flexible metal conduit and liquidtight flexible metal conduit in lengths longer than 1.8 m *(6 ft)* shall not be used as an effective ground-fault current path



Where equipment bonding jumpers *(internal or external)* are installed, they shall comply with 250.102 *(installation of bonding jumpers, etc.)*

Bonding of Piping Systems

- Metal water piping and other metal piping systems installed within or attached to buildings or structures required to be bonded
- Bonding requirement is not to be confused with metal underground water piping used as a grounding electrode *[see 250.52(A)(1)]*
- Some bonding requirements change depending upon whether the piping is metal water piping or other metal piping systems
- See 250.104 for bonding of metal piping systems

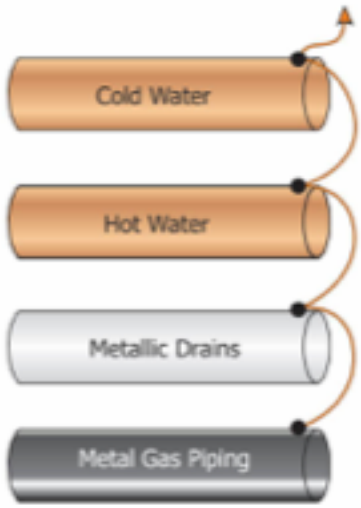
Bonding Metal Piping Systems

Applies to interior as well as exterior metal piping systems

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

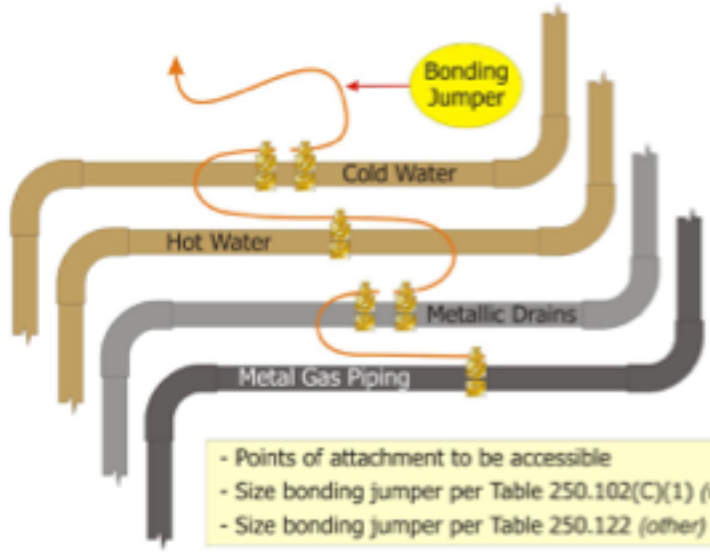
Other metal piping: Bonding jumper to be sized based on Table 250.122 for the circuit that is likely to energize the other metal piping system(s)

Note: Points of attachment of the bonding jumper(s) to be accessible



See 250.104(A) and (B)

Bonding Jumper Connection to be Accessible



- Points of attachment to be accessible
- Size bonding jumper per Table 250.102(C)(1) *(water)*
- Size bonding jumper per Table 250.122 *(other)*

See 250.104(A) and (B)

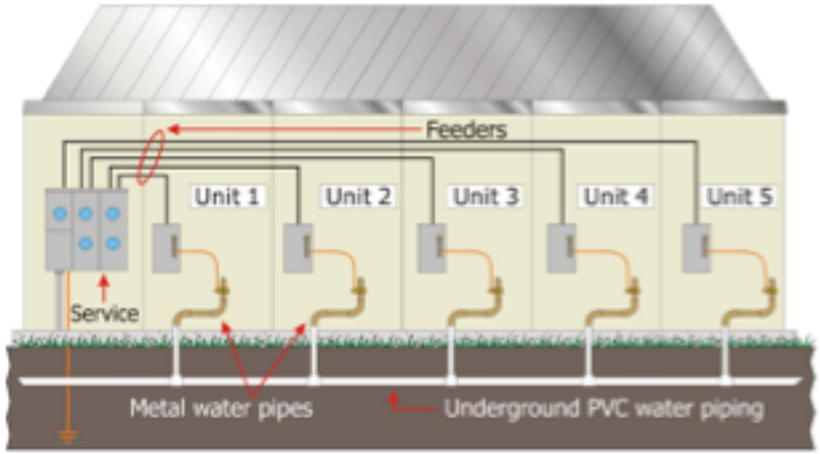
Bonding of Metal Water Piping Systems

- Metal water piping system(s) installed in or attached to a building or structure must be bonded per 250.104(A)
- Size bonding jumper per 250.102
- Attachment of bonding jumper to be accessible
- Attach bonding jumper to:
  - Service equipment enclosure
  - Grounded conductor at the service
  - Grounding electrode conductor if of sufficient size
  - One or more grounding electrodes used *(GEC or bonding jumper to be of sufficient size)*

Bonding of Metal Water Piping (Multiple Occupancies)

- Metal water piping system(s) allowed to be bonded to the panelboard or switchboard enclosure *(other than service equipment)* under specific conditions:
  - Building is multiple occupancy, and…
  - Metallic water piping is isolated from all other occupancies by nonmetallic water piping (*nonmetallic means or individual isolation)*
- Bonding jumper sized in accordance with Table 250.122, based on the rating of the overcurrent protective device for the circuit supplying the occupancy
- See 250.104(A)(2)

Metal Water Piping Bonding Alternative



Metal interior water pipes permitted to be bonded to panelboard in multiple occupancy buildings under the conditions provided in 250.104(A)(2)

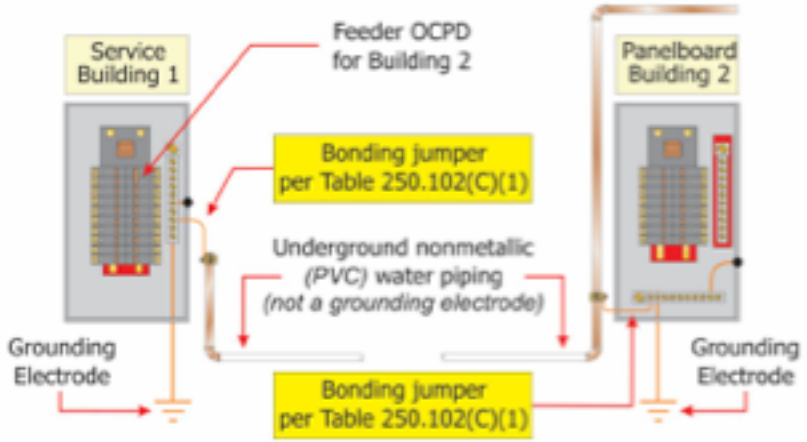
Size bonding jumper(s) in accordance with 250.122 based on the rating of the feeder OCPD

Bonding of Metal Water Piping (Multiple Buildings) *(cont.)*

- At **multiple buildings** or structures supplied by **feeder(s) or branch circuit(s)**, the metal water piping system(s) shall be bonded to one of the following:
  - Building or structure disconnecting means enclosure
  - EGC run with the supply conductors
  - One or more grounding electrodes used
- Size bonding jumper(s) 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
- The bonding jumper is not required to be larger than the largest feeder or branch circuit supplying the building
- See 250.104(A)(3)

Metal Water Pipe Bonding Jumper Size

Multiple Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s)



Bonding jumper sized from Table 250.102(C)(1) based on the size of feeder or branch circuit conductors that supply additional building(s) or structure(s)

See 250.104(A)(3)

Bonding of Other Metal Piping Systems

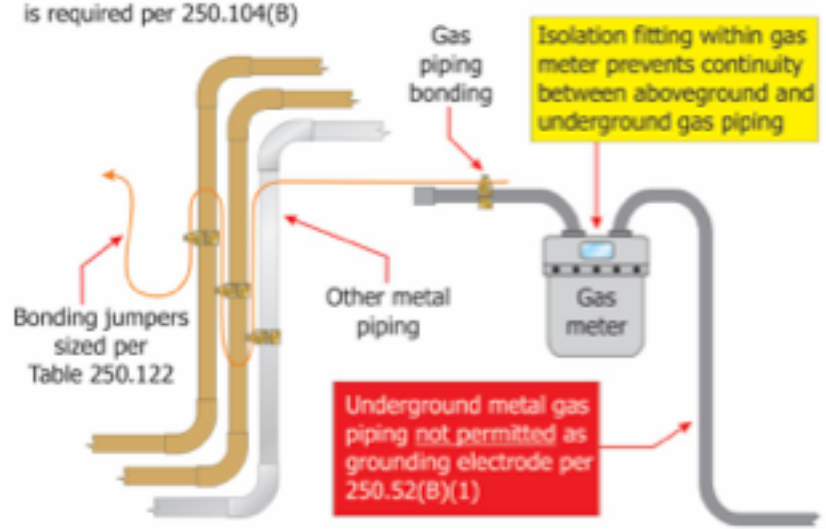
- If installed in or attached to a building or structure, metal piping system(s) ***(including gas piping)*** that is **likely to become energized** shall be bonded to any of the following:
  - EGC for the circuit that is **likely to energize the piping system**
  - Service equipment enclosure
  - Grounded conductor at the service
  - Grounding electrode conductor *(if of sufficient size)*
  - One or more grounding electrodes used *(GEC or bonding jumper to be of sufficient size)*

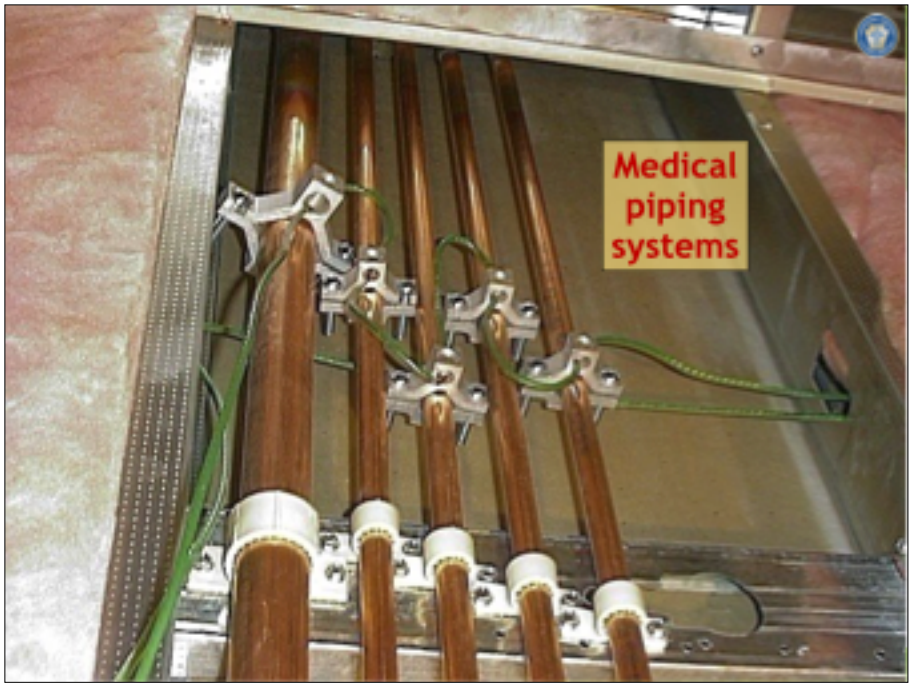
Bonding of Other Metal Piping Systems *(cont.)*

- Minimum size bonding jumper per **250.122** based on the **circuit likely to energize the piping system**
- Equipment grounding conductor of supply circuit may be used as bonding means
- NFPA 54 *(National Fuel Gas Code)* also requires metal gas piping system(s) to be bonded, which correlates with the requirements of the *NEC*
- See 250.104(B)

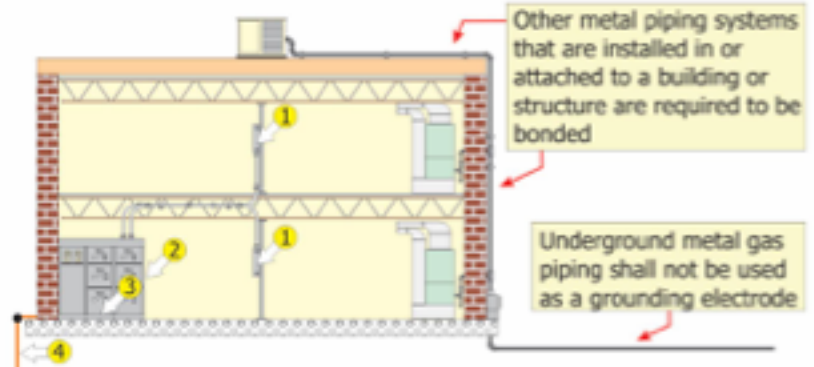
Bonding of Other Metal Piping Required

Bonding of other metal piping systems *(including metal gas piping systems)* is required per 250.104(B)





Bonding of Other Metal Piping Required



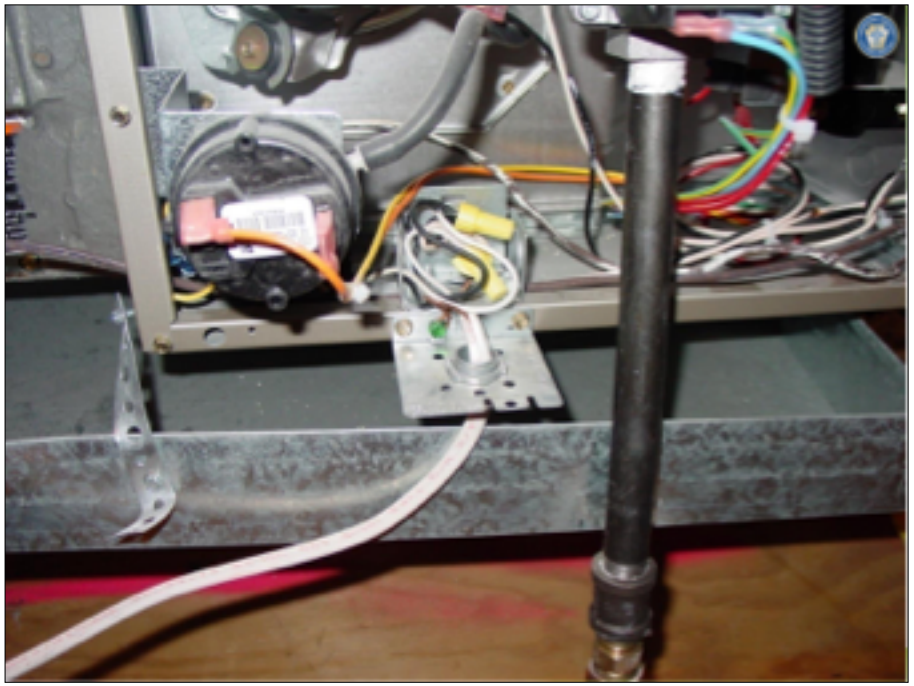
Other metal piping permitted to be bonded to:

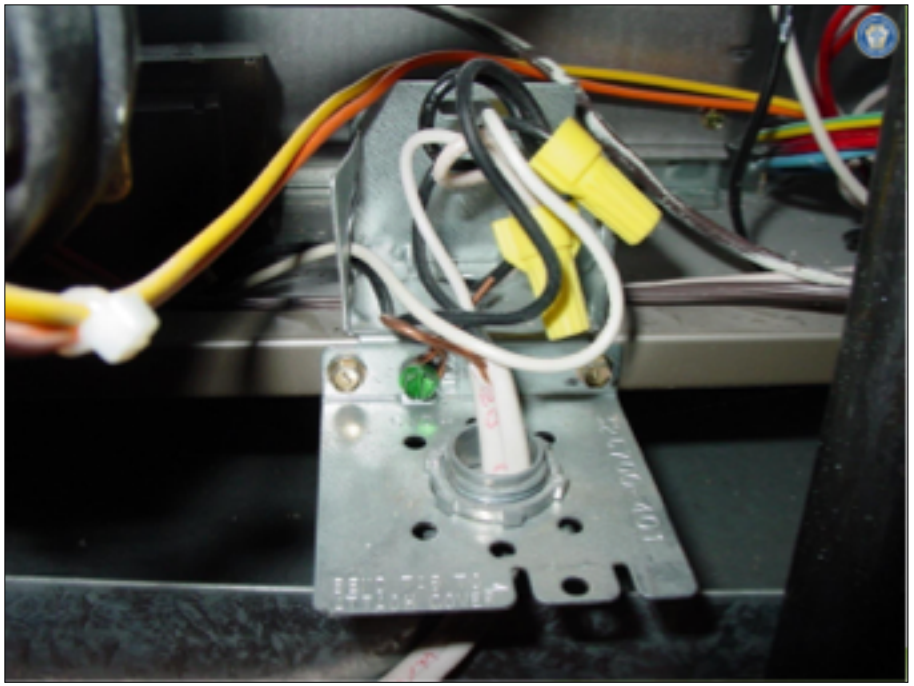
1. Equipment grounding conductor of circuit that may energize piping
2. Service equipment enclosure
3. Grounded conductor at service
4. Grounding electrode conductor *(where large enough)*
5. One or more grounding electrodes used

See 250.104(B)

Bonding of Other Metal Piping Systems *(cont.)*

- **Bonding of Gas Piping:**
  - If installed in or attached to a building or structure, metal gas piping that is likely to become energized shall be bonded
  - The **equipment grounding conductor** for the circuit that is likely to energize the piping system can be used for **bonding** of the gas piping
- See 250.104(B)





Bonding Structural Steel

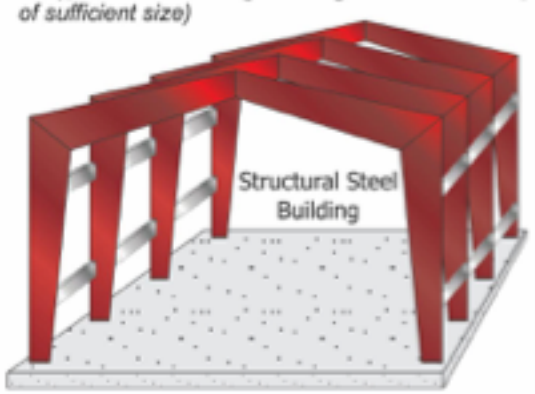
- **Exposed structural metal** interconnected to form a steel building frame *(not intentionally grounded)* and is likely to become energized is **required to be bonded**
- Bonding connection required to be made to:
  - Service equipment enclosure
  - Grounded conductor at the service
  - Disconnecting means for buildings or structures supplied by a feeder or branch circuit
  - Grounding electrode conductor *(of sufficient size)*
  - One or more grounding electrodes used *(if GEC or bonding jumper is of sufficient size)*

Bonding Structural Steel *(cont.)*

- Applicable to interior or exterior structural framing members of buildings or structures
- Bonding jumper required to be sized in accordance with Table 250.102(C)(1) and installed in accordance with the rules in 250.64(A), (B) and (E)
- The points of attachment of the bonding jumper to the structural steel are required to be accessible *(unless installed in compliance with 250.68(A) Exception No. 2)*
- See 250.104(C)

250.104(C) Bonding Structural Steel

- Exposed structural metal framing *(not intentionally grounded)* and likely to become energized shall be bonded
- Bond to the service equipment enclosure, grounded conductor at service, disconnecting means for building, grounding electrode conductor *(of sufficient size)*, or one or more grounding electrodes used *(if GEC or bonding jumper is of sufficient size)*



- Size bonding jumper per Table 250.102(C)(1)
- Install per 250.64(A), (B), and (E)
- Attachment point(s) of bonding jumper to be accessible *(unless installed per 250.68(A) Ex. No. 2)*

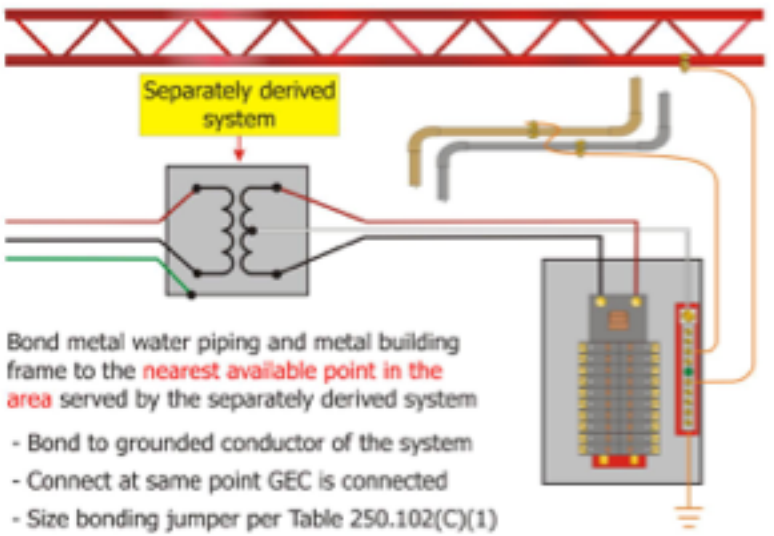
Bonding for Separately Derived Systems

- Metal water piping systems and structural metal building frame required to be bonded to separately derived systems in accordance with 250.104(D)(1) through (D)(3)
  - (D)(1) Metal Water Piping System(s)
  - (D)(2) Structural Steel
  - (D)(3) Common Grounding Electrode Conductor
- 250.30(A)(8) provides correlation between 250.104(D) and 250.30(A) *(grounding requirements for separately derived systems)*

Bonding for Separately Derived Systems (cont.)

- Bonding separately derived system is **necessary to establish a reference** to the metal water piping and structural metal in the area served by the separately derived system
- Area served can be determined by any equipment or outlets supplied from the separately derived system
- Bonding also provides a **fault-current path** in the event the metal water piping or structural metal becomes energized
- If a **common grounding electrode conductor** is used, it also must be bonded to the metal water piping and structural metal in the area

Separately Derived Systems-Bonding Structural Metal and Water Piping



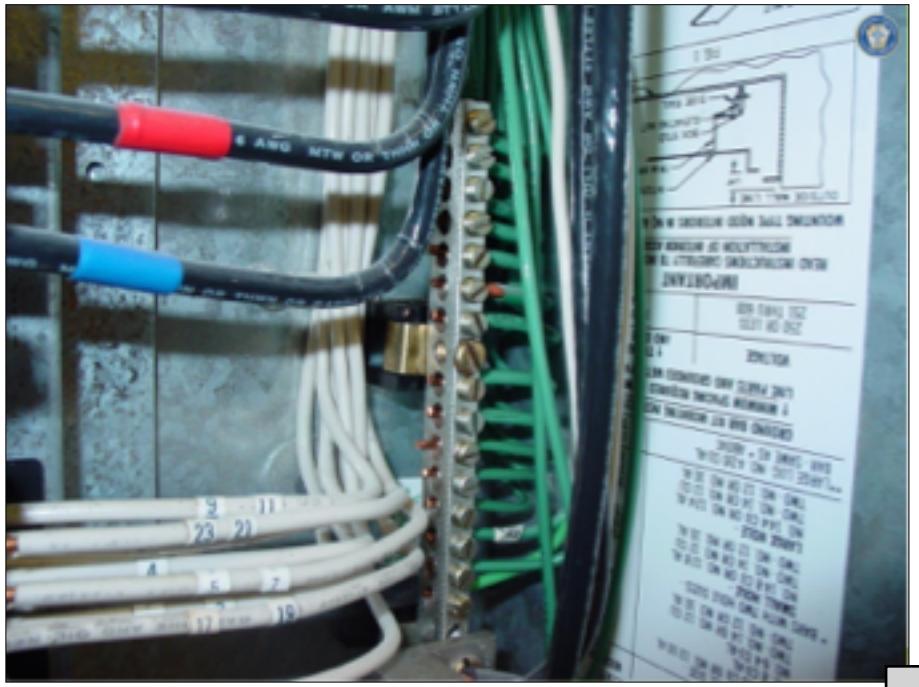
Bond metal water piping and metal building frame to the nearest available point in the area served by the separately derived system

- Bond to grounded conductor of the system
- Connect at same point GEC is connected
- Size bonding jumper per Table 250.102(C)(1)

See 250.104(D)

Chapter Nine: Equipment Grounding Conductors

- General requirements for equipment grounding conductors on grounded and ungrounded systems
- Sizing requirements for equipment grounding conductors
- Rules applied to multiple raceways or cables
- Rules for flexible cords
- Use of building steel that is properly grounded by an equipment grounding conductor
- Grounding of equipment by the grounded conductor



File Attachments for Item:

ER-4 Western Section IAEI Special Meeting (IAEI Western)

All certifications (18.5 hours)

Staff Notes: The submitter has made it clear that, despite the way he filled out the application, this two-and-a-half-day meeting is not a multisession course. If approved, it will receive one course number.

ESIAC Recommendation: Recommend approval.

Committee Recommendation:

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Thomas Moore

Organization: Western Section IAEI

Address: 3462 Brunk Road

E-mail: tmoore1767@gmail.com Telephone: (330) 289-7932

Website: http://IAEI-Western.org

Conference Sponsor (if applicable) Western Section IAEI Conference Email: tmoore1767@gmail.com

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Western Section IAEI Special Ohio Meeting

Course instructor: Thomas Moore (Multiple Presenters)

Course description: This will be a 2.5 day meeting. The educational presentation will consist of NEC 2023 Code Analysis 8.25 hrs. Code panel question and answers by nationally recognized code expert's and code making panel members 3.75 hrs. BBS & OCILB Reports by Regina Hanshaw and Carol Ross hrs. 1.5 - Ohio Required Instruction: Existing Buildings. 3 hrs. Solar Photovoltaic and Electrical Storage Systems Wendall Whistler CMP member hrs. 2

Instructional hours per session: 18.5 Number of Sessions: 5

Course Date(s) and Location: April 23 - 26, 2023 Encore Hotel & Hall 4365 St. Route 39, Millersburg, Ohio 44654

Special Content:

Code Administration: XX

Existing Buildings: XX

Electrical Instruction: XX

Plumbing Instruction: _____

Conference Course: _____

Conference Name: Western Section IAEI Special Ohio Meeting

Conference location: Encore Hotel & Hall Millersburg, Ohio 44654

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: XX

Administrative Course, All Certifications: _____

Application materials included:

XX Course Outline or Course Learning Objectives

XX Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

XX Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

Bret Johnston Bio

Journeyman Electrician since 1984
Master Electrician since 1994
Electrical Inspector for Sedgwick County (Wichita, Kansas) since 1992
Chief Building Inspector for Sedgwick County (Wichita, Kansas) since 2016
IAEI Member since 1993
Kansas Sunflower Chapter Secretary since 2012
Western Section President 2023

Christine Porter Bio

Intertek Testing Service Menlo Park CA
Christine Porter is a Field Evaluator – Conducting field evaluations of unlisted, modified, relocated, or used equipment for Intertek. She also provides Codes and Standards Training – Creating and providing classes and seminars for listing engineers, new field evaluators, as well as classes for Intertek clients, electrical & building trades associations, as well as code enforcement agencies on the applicable codes and standards. Christine taught in an electrical training/apprenticeship program for 32 years and earned Professor Emeritus from the Construction Industry Training College of Washington. Her duties included course development that involved creating training course material for electrical trainees and apprentices, as well as continuing education programs for certification purposes. She also earned recognition as a Subject Matter Expert (SME) from The National Center for Construction Education and Research (NCCER). She is a principal on CMP 5 covering the Grounding & Bonding requirements in NFPA 70, (NEC) National Electrical Code and a voting alternate on the Correlating Committee of NFPA 70 that correlates the requirements contained in NPFA 70, NFPA 70A, NFPA 70B, NFPA 70E, NFPA 73, NFPA 79, NFPA 110, NFPA 790, and NFPA 791. She is also an alternate on CMP 1 covering definitions and General Requirements in the NEC (NFPA 70). She serves as chair of NFPA 780 Standard for Installation of Lightning Protection Systems.

David Williams Bio

David Williams Electrical Inspector and Instructor, Delta Township, Michigan, and Lansing Community College. IAEI Code Panel 2008-2011-2014 CMP-5, Chair CMP-7 2017, 2020, 2023 CMP-10 and the NEC Correlating Committee. Master Electrician, Certifications: CEI-M, Certified Electrical Inspector-Master, IAEI, Electrical Inspector General and Electrical Inspector 1-2 Family. Dave serves on the UL Electrical Council and seven UL STP's. IAEI International Chairman of the Board of Directors 2022 and 2023. Secretary, IAEI-Michigan, Secretary NFPA Electrical Inspector Section.

Don Iverson Bio

Don Iverson is the Manager of Industry Codes & External Relations for Schneider Electric. His responsibilities are to support code adoptions on a national level as well as various roles within the business. Previously, Mr. Iverson was the Midwest Field Representative for the National Electrical Manufactures Association (NEMA). He has worked in the electrical field for over 22 years as a field electrician, apprenticeship instructor and, Electrical Inspector. He also holds a State of Michigan Electric masters & contractor's license and is a registered code official as an Electrical Inspector. Mr. Iverson is currently a member of NFPA 915, CMP 3 for the 2023 Representing Schneider Electric and past member of CMP 1 for the 2014, 2017 & 2020 NEC representing NEMA.

Gerald O'Connor Bio

Gerald has been with Eaton Corp. since August 2023 working in Electrical Codes & Standards. He was previously an electrical inspector with the City of Chicago for 6 years and is a part-time instructor with I.B.E.W. #134 technical institute in the greater Chicago area. He represented the IAEI on NFPA CMP-16 for the 2023 NEC and is waiting for approval as principal on CMP - 18. He also participates in NFPA 78 & 1078.

Jack Jamison Bio

Jack is the Chief Inspector with Jack E. Jamison, Jr. Inspections of Morgantown, WV. He holds a Bachelor of Science degree from Fairmont State University in Engineering Technology-Electrical Electronics. He is an ICC Master Code Professional, IAEI Certified Electrical Inspector Master, and a WV State Fire Marshall Class C Plans Examiner/Electrical Inspector. He is a founding member of the WV Chapter IAEI and currently serves as the Secretary and Education Committee. He has served as an IAEI Representative on the NFPA National Electric Code Making Panel for the last three code cycles on CMP 14, 18, and 11.

Joe Pavia Profile

Joe Pavia, P.E. is a Field Application Engineer with Eaton's Bussmann Business. He has over 30 years with Bussmann series solutions, specializing in training on the design and application of overcurrent protective devices and equipment in electrical distribution systems in accordance with the National Electrical Code® and equipment in accordance with the various product standards. He is a registered Professional Engineer for several States, serves on UL508C / UL61800-5-1 STP, NEMA SC07 committee and on Code Making Panel 11 for the National Electrical Code (NFPA 70). He also is active in various trade organizations including the Independent Electrical Contractors (IEC), International Association of Electrical Inspectors (IAEI), Institute of Electrical and Electronic Engineers (IEEE), National Electrical Manufacturer's Association (NEMA) and the National Fire Protection Association (NFPA).

Tim McClintock Bio

Tim McClintock has 36 years' experience in the electrical industry and is currently the National Electrical Manufacturers Association (NEMA) Midwest Technical Field Representative. In this role Tim serve NEMA members by promoting the use and adoption of the National Electrical Code® (NEC®) and by monitoring regional developments of importance to the electroindustry. Prior to joining NEMA, Tim was a Regional Electrical Code Specialist with the National Fire Protection Association (NFPA) providing support to state and local jurisdictions across 26 states with the adoption and use of the NEC® and other NFPA electrical codes and standards. Tim also served as the Chief Building Official and Electrical Inspector for the Wayne County Building Department in Wooster, Ohio for 16 years and prior to that, worked for nine years as an electrician for McClintock Electric Incorporated.

He served on Code Making Panel 12 for the 2008 and 2011 NEC code development cycle and also served as Chair of NFPA's Technical Committee on Electrical Equipment Evaluation, which is responsible for NFPA 790, Standard for Competency of Third-Party Field Evaluation Bodies and NFPA 791, Recommended Practice and Procedure for Unlabeled Electrical Equipment.

Tom Lichtenstein Bio

Tom Lichtenstein is a Sr. Regulatory Engineer and Distinguished Member of Technical Staff in the Codes and Regulatory Services Department at UL Solutions Northbrook Office. As an electrical engineer with UL for 33 years, Tom is UL's principal representative for NEC CMP-7 (formerly CMP-19) for seven code cycles and past alternate on CMP-1 for the 2011 NEC. In addition, was UL's representative for several

cycles on the Canadian Electrical Code (CEC), Part 1 committee and the Canadian Advisory Council on Electrical Safety (CACES) and is responsible for supporting the UL Mark for the Western Section of the International Association of Electrical Inspectors (IAEI) and providing technical presentations and support services for regulatory authorities.

Tom Moore Bio

Tom Moore, Akron Ohio, is past President of the IAEI Western Section, Ohio Chapter and Akron Division and past IAEI IO Board of Directors, Assistant Secretary/Treasurer of the Western Section IAEI' President and Membership Chair of the Akron Division IAEI. He has been involved in the inspection industry since 1987 and the electrical industry for over 50 years. Tom retired as the the Assistant Building Commissioner with the City of Beachwood Ohio and presently back building and electrical inspector for the City Stow and Portage County.

Tom has represented the IAEI on NEC CMP 11 for the 2005, 2008, and 2011code cycles and previously CMP 5 for the 2002 Code Cycle, Chair of CMP 16 for the 2014, 2017 and 2020, and presently Chair of CMP 8 code cycles. Tom is presently Chair of CMP 8. Additionally, served on NFPA 915 Standard for **Remote Inspections.**

Wendell Whistler Bio

Wendell Whistler was born in Juneau, Alaska in 1960. He graduated from Juneau-Douglas High School in 1978 and served his electrical apprenticeship in Alaska and graduated from the A.J.E.A.T.T. program in 1984. Wendell has also attended University of Alaska and Oregon State University enrolled in the Electrical Engineering program. Over his 43-year career as an electrician he has worked on the Alaska Pipeline and Seafood canneries helped build or maintain several small Alaskan airports, worked on nuclear power plants in California and has been on construction crews in many different states.
Wendell holds an Oregon Electrical Supervisors license, an Oregon OIC certificate, an Alaska Electrical Administrators license, Idaho Master Electricians License and Journeyman Electrical licenses in Alaska and Washington along with a NCSCB medium voltage cable splicers certificate. He is an approved instructor for both 10- and 30-hour OSHA courses and a MSHA above ground (24 hour) and under-ground (40 hour) instructor and an Extra class Amateur radio (HAM) license holder
Wendell started working as a follow-up services inspector for Intertek Testing in 2004 and then moved into doing field evaluations later that year. Became the team leader for the Western U.S.A. and coordinated 25 + field inspectors along with being a reviewer for the field reports. Most recently he worked for QPS America as a senior field inspector. Has numerous standards that he is competent is Such as UL 48, 1598, 73, 499, 61010-1, 508A, ISA 12.12.01
NFPA 70, 79, 99, 101.
Wendell began teaching apprenticeship and journeyman classes in 2000 and opened his own business, Whistler Consulting and Technical Services in 2002. Classes were approved in Alaska, Idaho, Oregon, and Washington.
Wendell is the former Apprenticeship Coordinator for the Central Electrical JATC and the former Training Coordinator for AJEATT in Fairbanks, AK.

Tom Lichtenstein Bio

Tom Lichtenstein is a Sr. Regulatory Engineer and Distinguished Member of Technical Staff in the Codes and Regulatory Services Department at UL Solutions Northbrook Office. As an electrical engineer with UL for 33 years, Tom is UL's principal representative for NEC CMP-7 (formerly CMP-19) for seven code

cycles and past alternate on CMP-1 for the 2011 NEC. In addition, was UL's representative for several cycles on the Canadian Electrical Code (CEC), Part 1 committee and the Canadian Advisory Council on Electrical Safety (CACES) and is responsible for supporting the UL Mark for the Western Section of the International Association of Electrical Inspectors (IAEI) and providing technical presentations and support services for regulatory authorities.

THE WESTERN SECTION IAEI
2023 WESTERN SECTION SPECIAL OHIO MEETING
OUTLINE AND TIME SCHEDULE

Registration
Pre-Function Area - Registration

Sunday, April 23, 2023- 2:00 pm until 5:00 pm
Monday, April 24, 2023 - 7:00 am until 9:00 am

Please check the hotel event board for any room changes

Sunday April 23, 2023

12.00 pm – 5:00 pm - **Registration**

1:00 pm – 2:00 pm Secretaries, Membership &
Education Chair Meeting

2:00 pm - **Opening of Exhibits**

2:00 pm to 5:00 pm **Ohio Chapter Board of Directors Meeting**

5:00 pm- Exhibit Area Closed

6:30-8:30 pm- **Welcoming Reception**

Monday, April 24, 2023

NOTE: 1.85 CEU's (1.85 contact hours) will be awarded for attending the complete educational program registration forms must be signed and submitted at the proper time for CEU's to be awarded. NO PARTIAL CEU's WILL BE ISSUED.
IO CEU Credits 1.8
Ohio BBS all Certifications 18.5 hrs.
Ohio OCILB all disciplines 18.5 hrs.

7:00 am – 8:00 am **Registration & Visit Exhibit Displays**

1. Call to Order- Welcome
-Bret Johnston, President-Western Section

2. Introduction of Color Guard -
TBD -

3. Pledge of Allegiance–
Bob Sallaz

4. Invocation
Bob Sallaz

5. Welcome to Millersburg
- Dave Hall – Holmes County Commissioner

6. -Western Section President Address-
-Bret Johnston, Kansas

7. Ohio Appointment of Nominating Committee
- Karl Fredrick -Ohio Chapter President

8. Address of IAEI Chairman of the Board
- David Williams, Lansing, MI

9. IAEI President/ CEO Report
-Rudy Garza, Richardson, TX

10. NFPA Report NFPA Regional Electrical Specialist
- Tim McClintock

11. Western Section Secretary Report
-Tom Moore, Akron, OH

12. Introduction of Manufacturers/Exhibitors

9:00 am- **NFPA Correlating Committee Report** 1 hr.
- Larry Ayre, Chair Correlating Committee
- David Williams, Correlating Committee & CMP 10

10:00 am- Coffee, Rolls and Visit Displays

Refreshments Courtesy of:
TBD

10:15 IAEI NEC 2023 Analysis 1.75 hrs.
- Don Iverson Schneider, Electric CMP 3
- Tim McClintock, NFPA

12:00 Noon- Recess for Lunch & Visit Displays
General Member's Luncheon

1:00 pm – **Code Panel 1 Forum – Your questions Answered by NEC Code Panel Members** 2 hrs.

Moderator: OP Post – Previous Past Ohio Chapter President

-Brian Deacy, Atkore Manufacturing
CMP 3 & CMP 5
-Tom Moore, City of Stow
CMP 8
-Gerald O'Connor Eaton Corporation

CMP 16
-Wendall Whistler QPS America
CMP 4
-Borgia Noel, State of Wyoming
CMP 6
-Tom Lichtenstein, UL
CMP 7

3:00 pm- **Break and Visit Displays**
Refreshments Courtesy of:
TBD

3:15 pm – **IAEI NEC 2023 Analysis** 1.75 hrs**.**
- Don Iverson Schneider, Electric CMP 3
- Tim McClintock, NFPA

5:00 pm- Adjournment

--- On Your Own Dinner

TUESDAY, SEPTEMBER 20, 2023

7:00 am - Coffee, Rolls and Visit Displays
Refreshments Courtesy of:
TBD

8:00 am – **Code Panel 2 Forum – Your questions Answered by NEC Code Panel Members** 1.75 hrs.

Moderator: OP Post – Previous Past Ohio Chapter President
-Don Iverson - Schneider Electric
CMP 1 & CMP 3
-Christine Porter - Intertek
CMP 6
-Steve Froemming – City of Franklin, WI
CMP 13
-Jack Jamison - WV Chapter IAEI
CMP 11
-Bob Fahey – City of Janesville, WI
CMP 18
- Joe Pavia Bussmann
CMP 13:

9:45 am- Break and Visit Displays
Refreshments Courtesy of:
TBD

Note: Display booths will be closing at 3:15 pm

10:00am – **IAEI NEC 2023 Analysis** 2 hrs.
- Don Iverson Schneider, Electric CMP 3
- Tim McClintock, NFPA

12:00 Noon- Recess for Lunch & Visit Displays
-General Member's Luncheon

Location TBD
-Ohio Board of Directors & Past Chapter &
Section President's Luncheon

1:00 pm- **Ohio Chapter Business Meetings**

1. Report of Board of Directors Meeting (Chapter Secretary)
2. Report of Nominating Committee
3. Election of Officers, Board of Directors Members
(Voting by Ohio Chapter Members only)

1:30 pm – 2:15 pm BBS Report Regina Hanshaw .75 hrs.

2:15 pm – 3:00 pm OCILB Report Carol Ross .75 hrs.

3:00 pm - Break and Visit Displays
Refreshments Courtesy of:
TBD

3:15 pm – **IAEI NEC 2023 Analysis** 1.75 hrs.
- Don Iverson Schneider, Electric CMP 3
- Tim McClintock, NFPA

5:00 pm - Adjournment

6:00 pm - **Reception, Banquet, Dinner**
Installation of Officers, Door Prizes &
Entertainment

WEDNESDAY, SEPTEMBER 22, 2023

7:00 am – **Photovoltaic Systems & Energy Storage Systems** 2 hrs.
Wendall Whistler
NEC CMP 4

9:00 am - Break
Refreshments Courtesy of:
TBD

9:15am – **Ohio Required Instruction: Existing Buildings** 3 hrs.
- Jay Richards BBS
- Mike Thompson DIC

12:15 pm- Adjournment of the 2023 Western Section Meeting

Note: IAEI IO and Ohio BBS CEU Certificates for All Attendees Who Submitted the For CEU's will be Available following Wednesday Adjournment. OCILB hours will be entered directly into the OCILB database.

The Western Section IAEI thanks all the members of the Ohio Chapter for making this Annual Meeting a Success

Please join us for our 2023 Annual Western Section Meeting September 17 – 20, 2023 at Oglebay Resort in Beautiful Wheeling, WV.

Inspecting Solar Panel Installations

- NEC Article 690
- Plan Review
- PV Modules and Arrays
- Nameplate
- Mechanical Attachment
- PV System Components
- Off Grid Solar Components
- PV Labeling
- Solar PV Priorities
- PV Layout
- Grounding
- Overcurrent Protection
- Inverters & Micro-Inverters
- Markings
- Disconnects
    - Rapid Shutdown
- UL Standards
    - UL 6703 Electrical Connections
    - UL 1741 Inverters & Controllers
    - UL 1703 PV Modules
    - UL 4703 PV wire
    - UL 2703 Mounting Systems
        - Racking

eurofins | E&E

Inspecting Solar Panel Installations

Presented By:
Wendell Whistler

INTRODUCTION

Testing Services

- Product Safety
- EMC
- Wireless/OTA
- Environmental Simulation
- Field Evaluation

196

Field Evaluations

- Typically required by AHJs or end users
- Custom equipment
- Certified equipment that has been modified
- CE-marked equipment
- Unlisted equipment

197

Field Evaluation Services

- **We are a resource for AHJs and Contractors**
  - Standards consultation
  - Continuing education
- **Code making panels**
- **Very active in IAEI**

198

Contact Information

Wendell Whistler - Senior Field Engineer

wendell.whistler@metlabs.com

Cell: (971) 289-6652

199

Inspecting Solar Panel Installations

200

NEC Article 690

Solar Photovoltaic (PV) Systems

Part I General

Part II Circuit Requirements

Part III Disconnecting Means

Part IV Wiring Methods

Part V Grounding and Bonding

Part VI Marking

Part VII Connection to other Sources

Part VIII Energy Storage Systems

201

Plan Review

What size PV projects require plan review?

Residential

Commercial

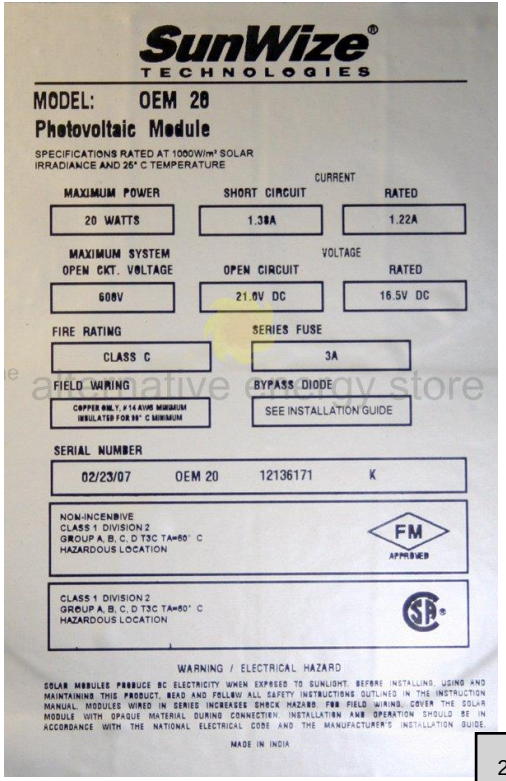
Large scale PV

PV Modules and Arrays

UL 1703 Standard for Flat-Plate Modules and Panels

- 110.3
- 690.4(B

Module Nameplate



Mechanical Attachment

- **Modules attached to the listed mounting structure the manufacturer's instructions {(110.3 (B)}**
- **Roof penetrations secure and weather tight {110.12, 110.13}**

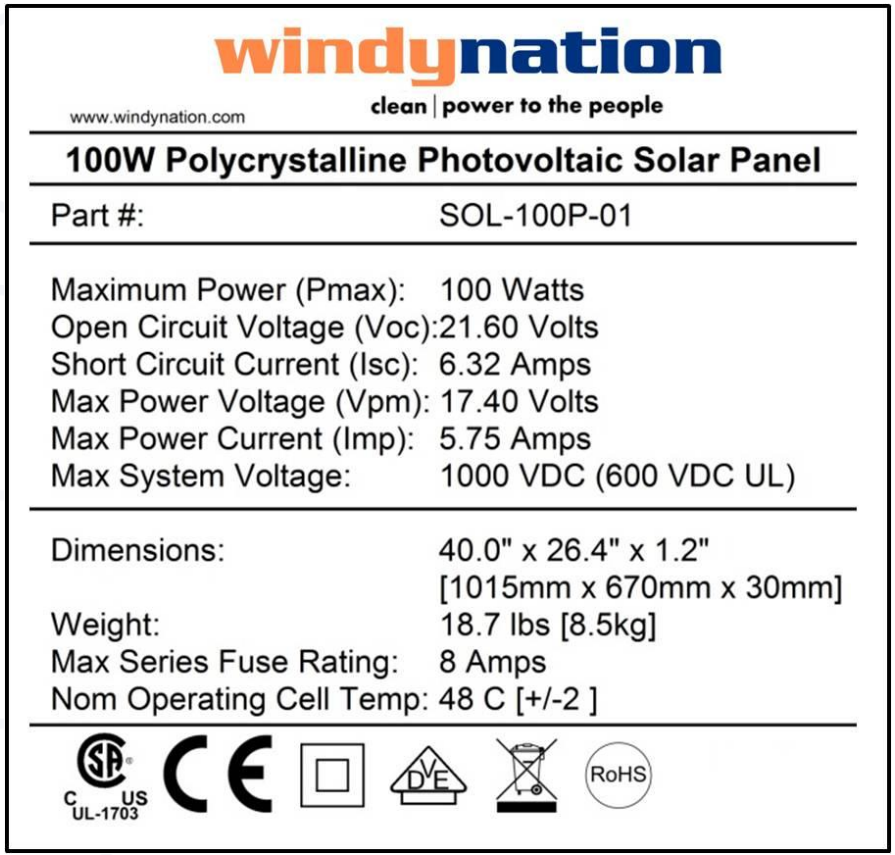
UL 2703

Standard for Mounting Systems, Mounting Devices, Clamping and Retention devices and Ground Lugs for use with Flat-Plate Photovoltaic Modules

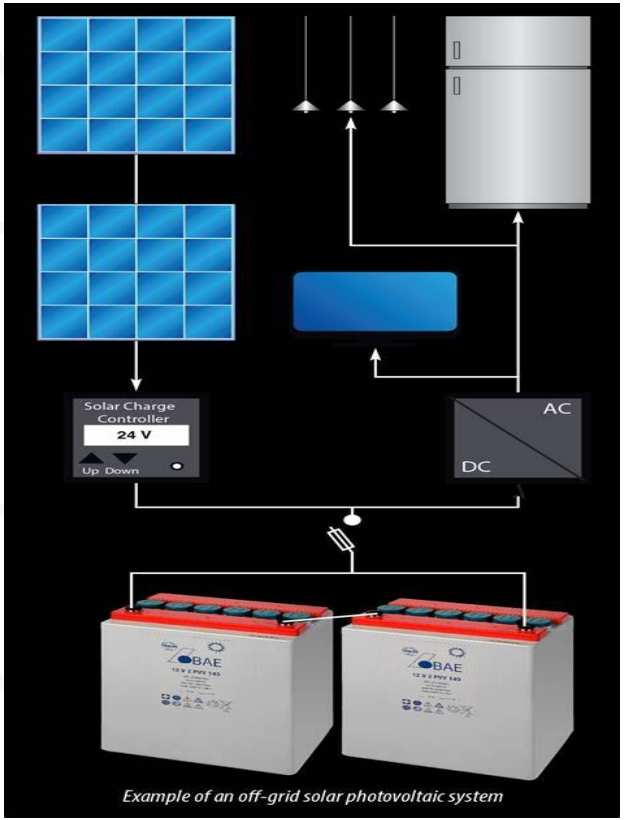
Racking

Racking

Module Nameplate Information

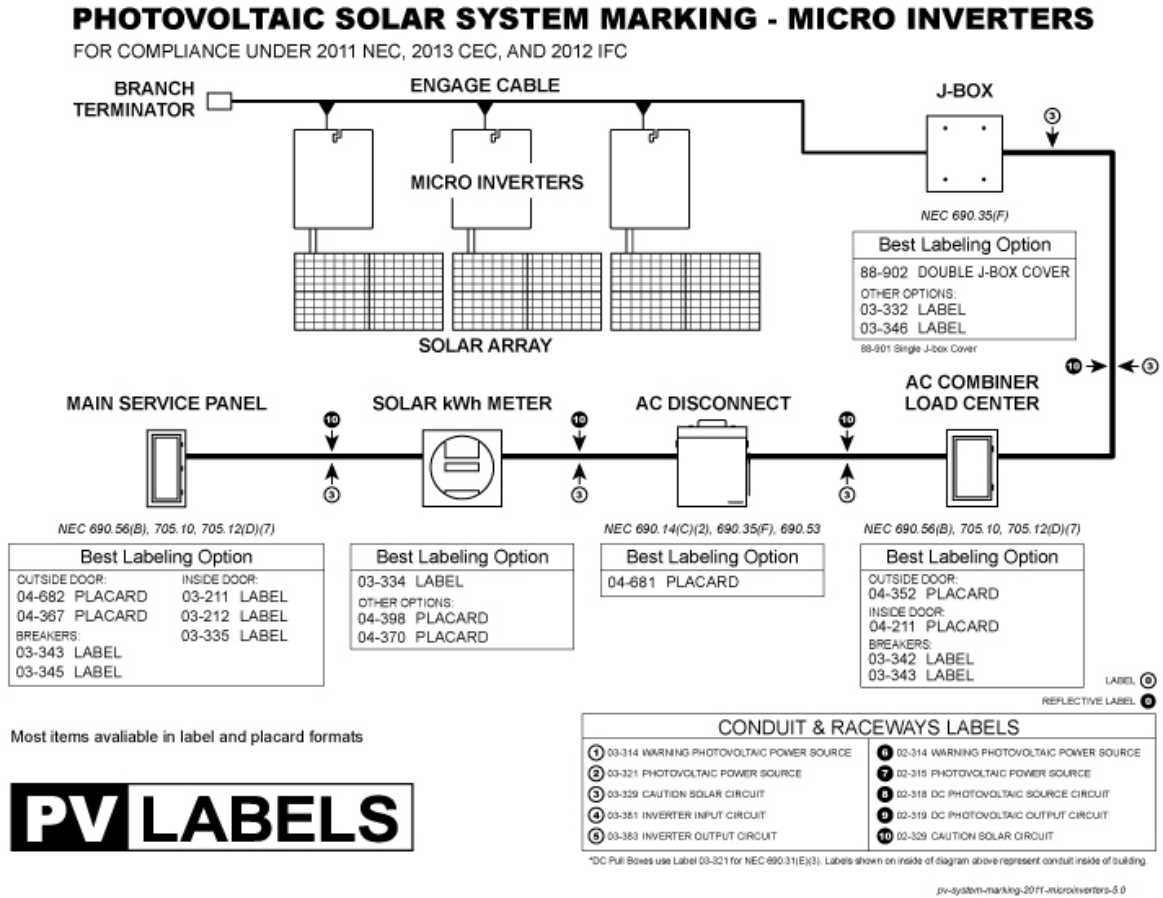


Off Grid Solar Components

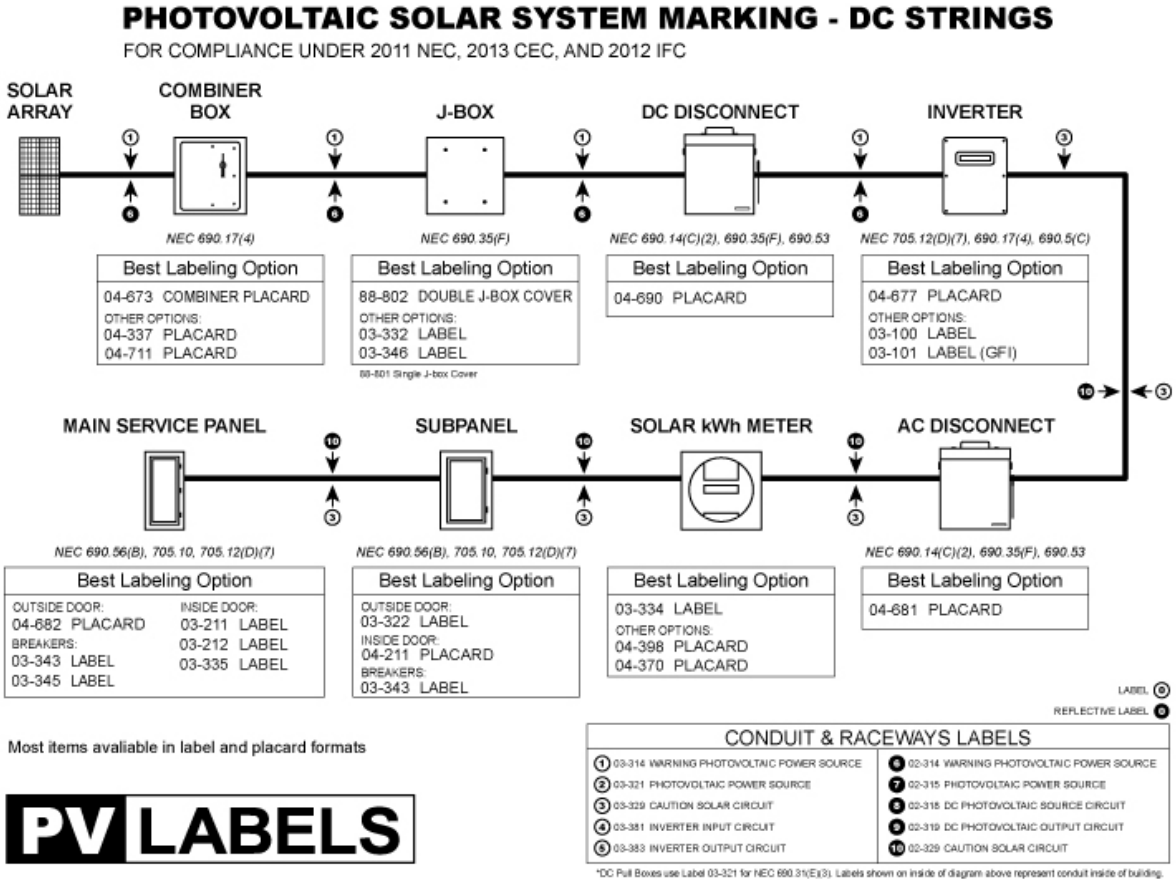


Example of an off-grid solar photovoltaic system

PV Labeling Micro-inverters



PV Labeling Micro-inverters



Solar PV Priorities

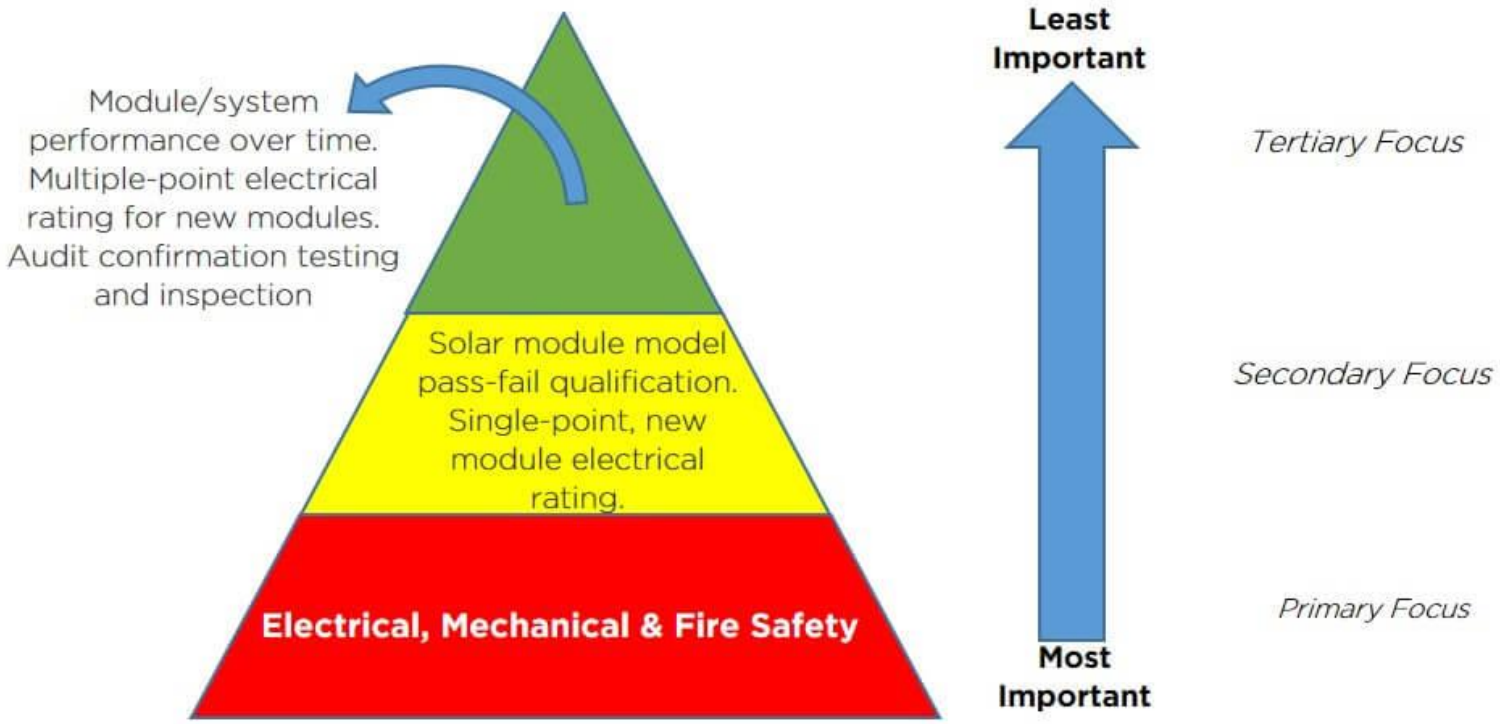
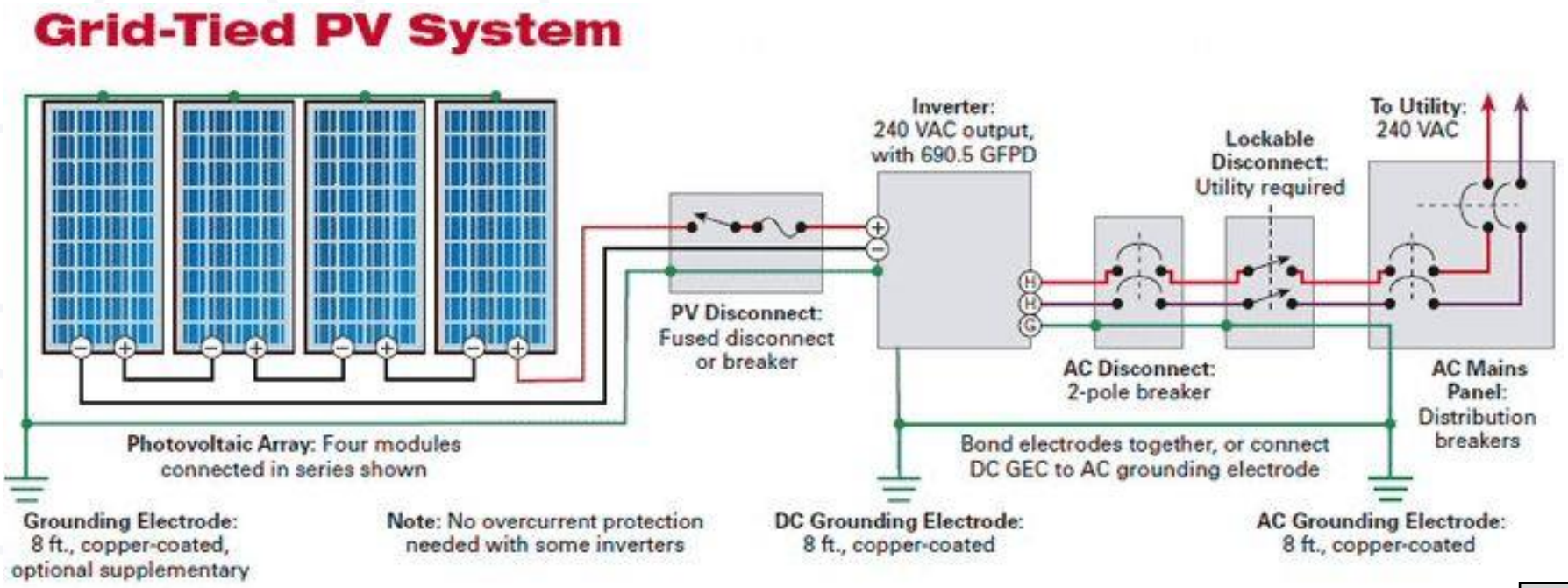
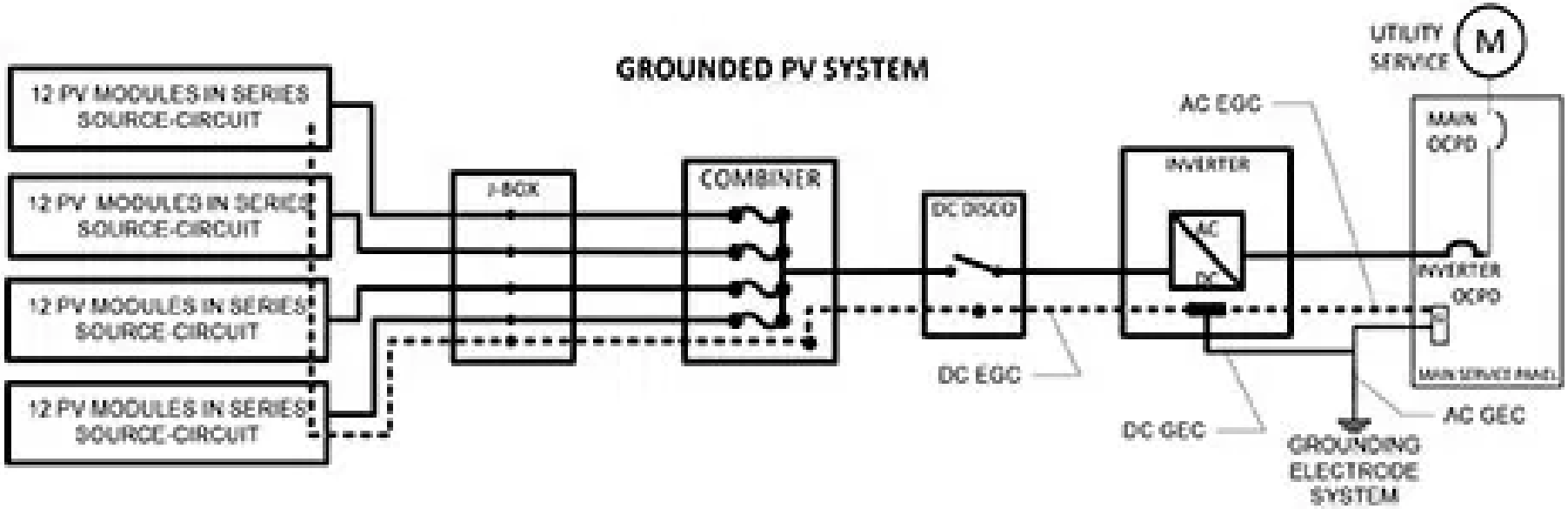


Figure 1. Hierarchy of Solar PV Priorities

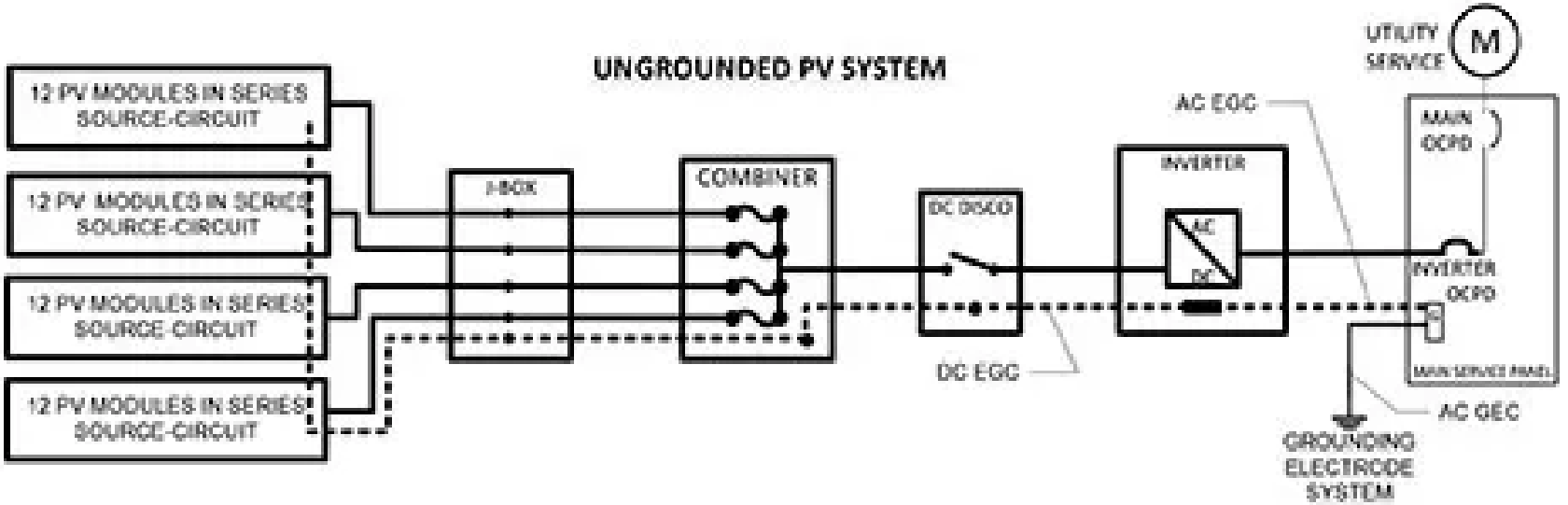
Layout of Grid Tie PV System



Grounded PV System



Ungrounded PV System



Grounding

Each module grounded using supplied hardware, the grounding point identified on the module and the manufacturer's instructions.

Bolting the module to a grounded structure usually will not meet the NEC requirements in 110.3(B) and may not comply with the installation instructions for grounding the PV module.

Array PV mounting racks are usually not identified as equipment grounding conductors unless listed to UL 2703

Grounding

690.43

Module instruction manual must specifically show or indicate grounding and mounting methods.

690.45

Properly sized equipment grounding conductors (EGC) routed with the circuit conductors

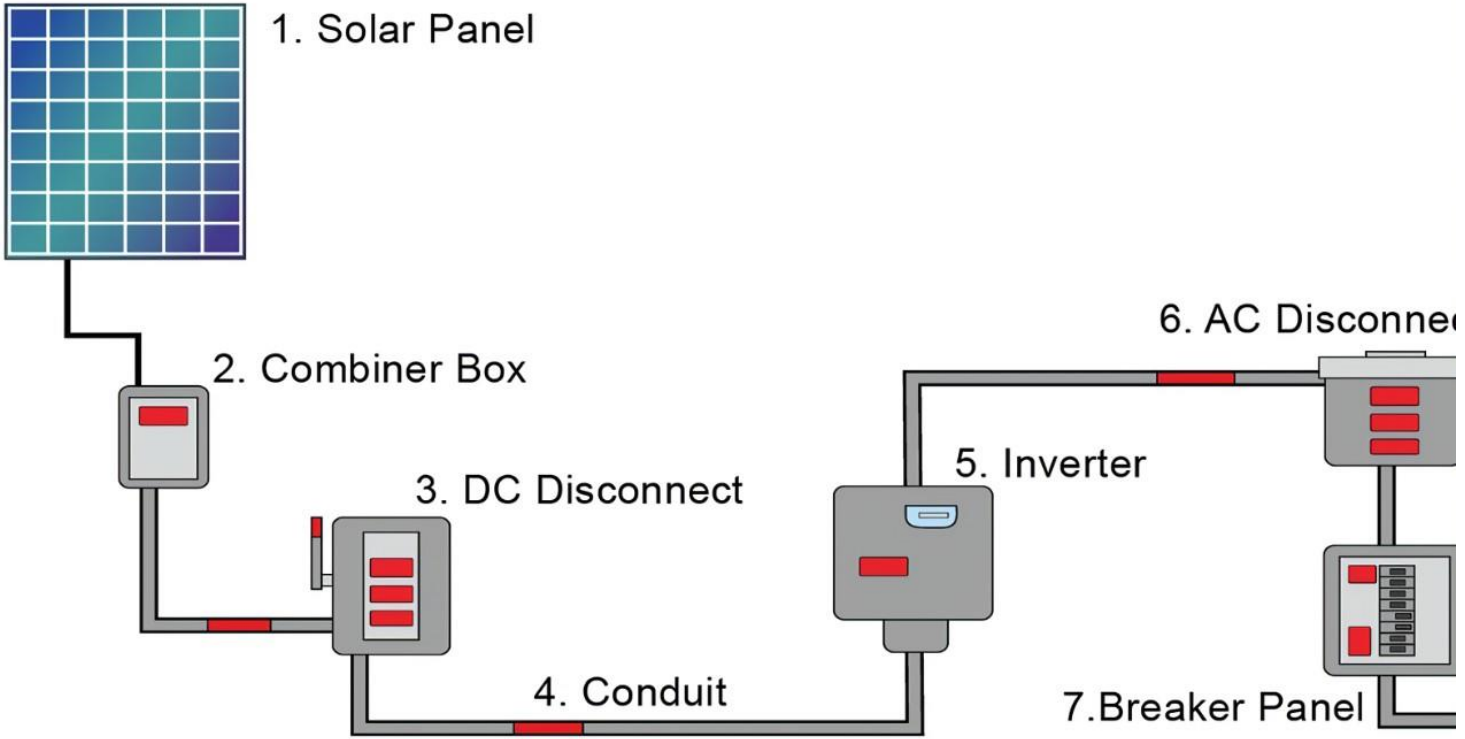
Listed PV grounding clamps

Means of grounding terminations

Grounding Terminations

http://www.solarabcs.org/about/publications/reports/systemgrounding/pdfs/SystemGrounding_studyreport.pdf

PV System Components



Conductors

Standard for Photovoltaic Wire

UL 4703

Conductors


UL 4703
PV WIRE
Photovoltaic
MADE IN
U. S. A.
UNLIMITED SOLAR


E339768 (UL) PV Wire 10AWG 90°C Dry

Conductors

Listed Conductors UL 4703

Conductor Type-

If exposed USE-2 or PV wire for grounded PV arrays

All PV modules will use PV wire

2017 NEC allows USE-2 or PV wire for both grounded and ungrounded systems

Conductor Insulation

Conductor insulation rated at 90 degrees C (UL 1703) to allow for operations 70 degrees C near modules and in conduit or cables exposed to sunlight {Table 310.15 (B) (3) (c)}

Temperature corrected ampacity calculations based on 125% of short circuit current (Isc) or the 156% Isc without conditions of use.

Use the worst case

Conductor Temperature Correction

Suggest temperature derating factors of 65 degrees C for conductors behind modules in installations where the backs of the modules receive cooling air (4 “ or more from the roof)

Suggest temperature derating factors of 75 degrees C for conductors behind modules in installations where no cooling air can get to the backs of the modules

Ambient temperatures near and at the array location of more than

40 degrees C may require different derating factors

Overcurrent Protection

Overcurrent devices in the DC circuit listed for DC operation?

If device is not marked for “DC” verify listing with the manufacturer

Auto, Marine and Telecom devices are not acceptable

In PV circuits OCPD must be listed as a PV device {690.9 (B)}

Rated at 156% (1.25 x 1.25) short circuit current from modules?

{UL 1703, 690,8 and module instructions}

Overcurrent devices listed for PV applications are required

{690.9(B)}

Overcurrent Protection

- **Each module or series string of modules have an overcurrent devices protecting the module(s)?**
- **<u>Frequently installers ignore this requirement marked on the back of the modules</u>**
- ***Listed combiner boxes meeting this requirement are available. One or two strings of modules do not generally require overcurrent devices, however three strings or more in parallel will usually require an overcurrent device. The module maximum series fuse must be at least 1.56 Isc. {690.9(A)}***

Overcurrent Protection

- Only one conductor of and ungrounded PV source or PV output circuit is permitted to have and Overcurrent Protective Device (OCPD).
- If used other OCPD’s in the dc circuit must be in the same polarity
- Located in a position in the circuit to protect the module conductors from back-fed currents from parallel module circuits or from the charge controller or battery? {609.9(A)}

Overcurrent Protection

- **Is the smallest conductor used to wire modules protected? Sources of overcurrent are parallel connected modules, batteries and ac back feed through inverters. {690.9(A)}**

- **Are User accessible fuses in “touch safe” holders or fuses capable of being changes without touching live contacts? Disconnect form all sources of voltage in dc combiners at the inverter? {690.16}**

Electrical Connections

UL 6703 Standard for the use in Photovoltaic Systems

Electrical Connections

- Pressure terminals tightened to the recommended torque specifications? {110.3(B), 110.14}
- Crimp-on terminals listed and installed with the listed crimping tools by the same manufacturer? {110.3 (B)}
- Twist on wire connectors listed for the environment (dry, damp, wet or direct burial) and installed per manufacturer's instructions?

Electrical Connections

- Pressure lugs or other terminals listed for the environment? (inside, outside, wet or direct burial)
- Power distribution blocks (PDB) listed and not just a recognized ?
- Terminals containing more than one conductor listed for multiple conductors?
- Connectors or terminals using flexible fine stranded conductors listed for use with such conductors? {690.321(H), 690.74 (A), 110.14}
- Locking connectors (tool required) on readily accessible {V conductors operating at over 30 volts? {690.33 (C)}

Charge Controllers

- Charge controllers listed to UL 1741? {690.4(B)}
- Exposed energized terminals not readily accessible?
- Does the diversion controller have an independent back-up control method {706.23 (B) (1)}

Disconnects

- **Rapid shutdown system installed? {690.12}**
- **Applied to inverter inputs, module outputs, batteries and combiner outputs.**
- ***Listed equipment is available and the UL Standards addressing the requirements are published.***
- **Rapid Shutdown operation verified?**
- **Disconnects listed for dc operation in DC circuits?**
- **PV disconnect readily accessible and located at the first point of penetration of the PV conductors? (Location not specified)**

Disconnects

- **PV conductors outside of the structure until reaching the first readily accessible disconnect unless in a metallic raceway? {690.13(A) & 690.31 (F)}**
- ***Metallic raceway now required all of the way to the inverter dc input***
- **Disconnects for all current carrying conductors for the PV system? {690.13}**
- **PV system disconnect must disconnect all circuit conductors even on solidly grounded systems. However solidly grounded conductors should not be opened.**

Disconnects

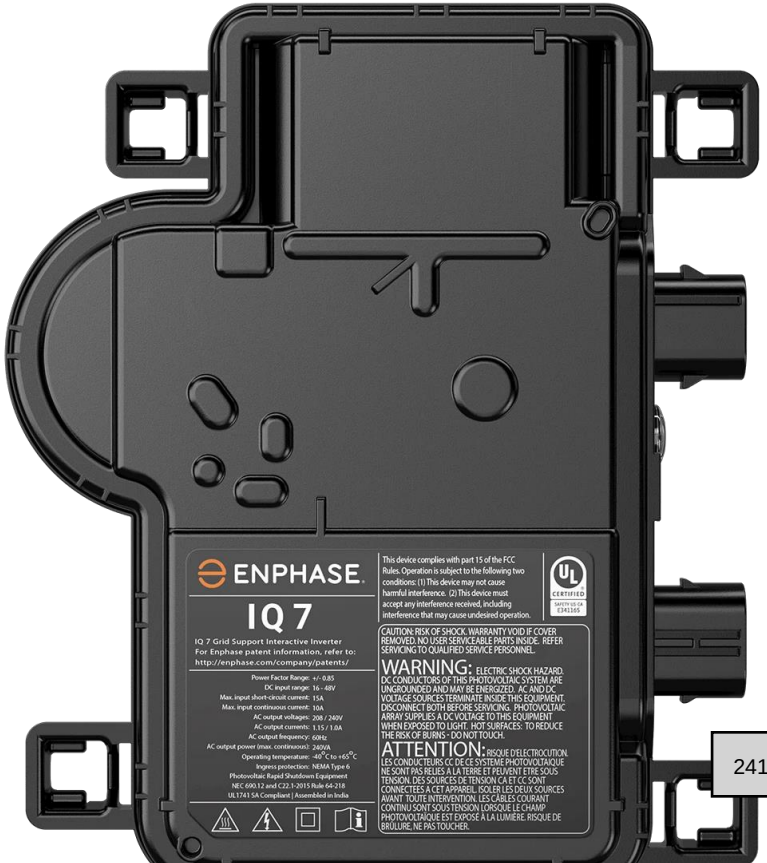
- Disconnects for equipment? {690.15 & 690.17}
- Equipment isolation disconnects may disconnect only the ungrounded conductor
- DC combiner has output circuit disconnect/isolator internal or within 10 ft? {690.15(A)}

Disconnects

- Grounded conductors are NOT fused or switched except PV system disconnect?
- Listed PV Power centers are available for 12, 24 and 48-volt systems. They contain charge controllers, disconnects and overcurrent protection for the entire dc system with the possible exception of the source circuit and module protective devices

Inverters

Micro-Inverters



Inverters

- Stand Alone systems
- Inverters listed to UL 1741 {110.3(B) 690.4 (B)}
- DC input current from the battery calculated for conductor and fuse requirements? Input current equals rated ac output in watts divided by the lowest battery voltage divided by the inverter efficiency at that power level {690.8 706.20}
- Cables to batteries sized at 125% of the inverter input current? {609/8(a) 706.20}

Inverters

- Overcurrent/Disconnects mounted near batteries and external to PV load centers if conductors are longer than 4-5 feet to batteries or inverter.
- High interrupt listed DC-rated fuses or circuit breakers used in battery circuits? Ampere Interrupt Rating at least 20,000 amps {706.21 110.9 110.10}
- No multi-wire branch circuits where 120-volt inverters are connected to 120/240 volt load centers. {710.15}

Batteries

- NO separate battery cells are listed
- AC battery systems are generally self-contained and will be listed as an assembly
- Building wire type cabling used?
- Must be a Chapter 3 type conductor. No welding cable , DLO, appliance wire (AWM) or automotive battery cables. Do NOT meet NEC. Listed flexible RHW and THW cables available. Flexible cable 2/0 and larger for battery cell connections {690.74 400.8}. Fine stranded (Class K) cables require special listed terminations {110.14 690.74}

Batteries

- Access limited? {706.30}
- Installed in well ventilated areas? {706.10 (A)}
- Have the conductor routing requirements in 706. 20 and 706.32 been met?
- Cables to inverters, dc load centers and/or charge controllers in conduit?
- Conduit enters the battery enclosure below the terminals of the flooded batteries? {300.4} There are a few listed battery boxes. Lockable heavy-duty plastic polyethylene toolboxes are usually acceptable

Utility Interactive Inverter Systems

UL 1741

- **Standard for Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources**
- **Identified for use in interactive photovoltaic power system {690.4(B) 705.4}**
- **Back-up charge controllers to regulate the batteries in the systems with multi-mode inverters when the grid fails. {706.23(B)}**
- **Connected to dedicated branch circuits with back-fed overcurrent protection?{705.12(B)} or connected as a supply side connection with overcurrent protection within 10 feet? {705.12(A) 705.31}**

Utility Interactive Inverter Systems

- Listed dc and ac disconnects and overcurrent protection?{690.15 690.17}
- All requirements of 705.12 (A) or 705.12(B) met?
- Square wave or modified sine wave inverters may be listed to UL 1741 but are not compatible with many power tools battery chargers, smoke alarms and other listed electronic devices and should NOT be used. The manufacturer’s instructions will usually have a warning statement {110.3(B)}

Grounding

- Only one bonding conductor (ground only on solidly grounded PV systems) for DC circuits on grounded PV arrays and one bonding conductor for ac circuits (neutral to ground) for ac system grounding
- ***Utility interactive inverters will generally provide the "Functional ground" for the system. Instructions for "functional ground will be in the inverter instruction manual***
- System inverter grounding meets requirements of 690.47?
- EGC properly sized? {690.43 690.45 690.46}

Grounding

- Disconnects and overcurrent in both ungrounded conductors in each circuit on 12-volt, ungrounded systems or on ungrounded systems of any voltage {690.9 690.13 690.15 690.31}
- Functionally grounded PV systems will not have any DC PV source or output conductors with white insulation
- Bonding-grounding fittings or bushings used with metal conduits when dc system voltage is more than 250 volts DC? {250.97}
- Grounding-bushings used where grounding electrode conductors are in metallic raceways or enclosures?

Conductors

- Standard building wire cables and wiring methods are used? {300.1 (A)}
- Wet rated conductors used in conduits in exposed locations?
- Conductor insulations other than black will NOT be durable in outdoor UV-rich environments
- DC color codes; are they correct?
- Same as AC color codes for grounded and grounding {200.6 (A)}
- Ungrounded PV array conductors on ungrounded PV arrays will NOT be white in color. White only used in solidly grounded PV systems {690.41}

Markings

- All field-applied markings; are they correct?

  {690.13 690.31(B) 690.51 690.53 690.54 690.55 705.10 705.12}

- Meet color and letter size requirements? {690.56}

DC PV Arc Fault

- Photovoltaic (PV) DC Arc-Fault Circuit Protection UL 1699 B
- Usually installed in the inverter or on larger systems in the array field. May be multiple devices {690.11}

PV Rapid Shutdown

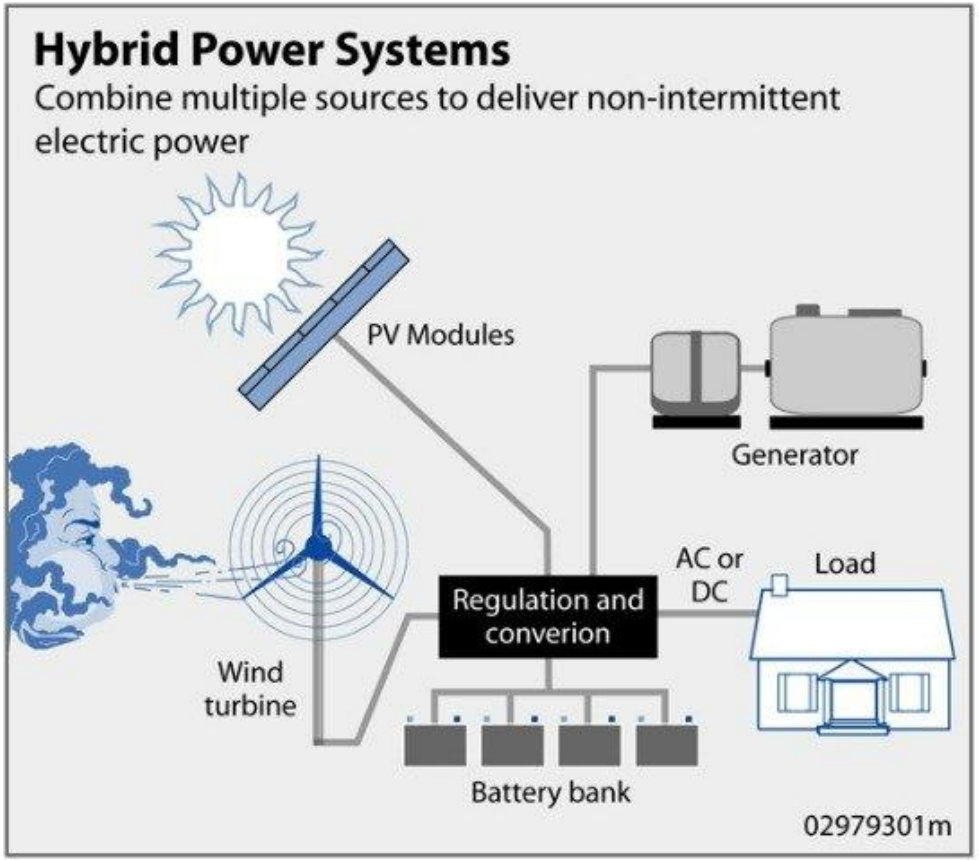
Installed per NEC 690.12 and local requirements?

Operational?

Article 691

- Large Scale Photovoltaic (PV) Electric Power Production Facility
- 5 Mega-watts and Larger
- Independent Power Producer

NEC Article 705



Combiner box

Combiner Boxes

Standards

- Rack Mounting products to UL 2703
- Modular Framing Systems to ICC AC 428
- Solar Trackers to UL 3703
- Junction Boxes to UL 3730
- Wiring Harnesses to UL Subject 9703
- Connectors to UL 6703

Standards

- Power Ratings to IEC 61853-1
- Inverters to IEC 62109-2
- UL1741 (Inverters, Combiner boxes, DC Optimizers, Charge Controllers)
- IEEE 1547.1 (Grid Interaction Equipment)
- UL4703 (PV Wire)
- UL/ULC ORD C1703 (PV Modules)
- IEC61730 (PV Modules Safety Requirements)
- IEC61215 (Performance Requirements for PV Modules)

Photovoltaic Power Systems

For Inspectors, Plan Reviewers 7 Professionals

Third Edition

John Wyles

International Association of Electrical Inspectors

eurofins | E&E

Thank you for attending

Questions?

eurofins | E&E

Wendell Whistler - Senior Field Engineer
wwhistler@qpsamerica.com
971 289 6652

File Attachments for Item:

EC-1 2021 IBC Accessibility and A117.1-17 (ICC)

All certifications (4 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura orris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club ills, IL 047

E-mail: lmorris iccsafe.org Telephone: -422-7233 xt 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 IBC Accessibility and the A117.1-17 Standard

Course instructor: Jay Woodward

Course description: This session focuses on the general requirements for the construction of accessible commercial buildings and residential facilities for compliance with the IBC and ICC A117.1 Accessible and Usable Buildings and Facilities. It addresses the key issues involving the design, plan review and inspection of buildings and facilities to ensure that individuals with physical, visual or hearing impairments can use the facilities.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: 5/3/2023 / Tampa Bay, FL

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

X Assessment Materials (for online courses)

_____ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2021 IBC Accessibility and the A117.1-17 Standard

Description

This session focuses on the general requirements for the construction of accessible commercial buildings and residential facilities for compliance with the IBC and ICC A117.1 Accessible and Usable Buildings and Facilities. It addresses the key issues involving the design, plan review and inspection of buildings and facilities to ensure that individuals with physical, visual or hearing impairments can use the facilities.

Learning Objectives

Upon completion, participants will be better able to:

- Recognize which accessibility requirements are enforceable by the building official.
- Determine the extent to which accessibility code provisions apply to the design and construction of any facility, as well as the alteration or change of occupancy of an existing building.
- Identify the basis for the technical requirements set forth in the referenced standard.
- Identify scoping and technical requirements for:
  - Exterior accessible routes (accessible routes criteria, accessible parking spaces, curb ramps and signage);
  - Accessible entry and means of egress (entrances, means of egress, areas of refuge);
  - Interior accessible routes (accessible route criteria, elevators, lifts, ramps and doors);
  - Building features and facilities (toilet and bathing facilities, drinking fountains and customer service facilities.
  - Dwelling and sleeping units (transient lodging and institutional units);
  - Existing structure requirements in the 2021 *International Existing Building Code* (IEBC)®

Outline: 4-hours = 240 minutes

I. Overview: Introduction and what will be covered (15 minutes)
   a. Basis for Technical Requirements

II. Module 3: Dwelling units and sleeping units (35 minutes)
   a. Types of units and key terms
   b. Counting units
   c. Scope of Accessibility provisions Group I and R

III. Module 4: Special occupancies requirements (25 minutes)
   a. Classroom acoustics

IV. Module 5: Exterior accessible route (20 minutes)
   a. Arrival points, entrance and route
   b. Curb ramps and blended transitions
   c. Accessible parking

V. Module 6: Accessible entry and exits (55 minutes)
   a. Accessible entry
   b. Accessible means of egress
   c. Emergency planning
   d. Notification and communication
   e. Special consideration

VI. Module 7: Interior accessible route elements (30 minutes)
   a. Technical requirements
   b. Doors
   c. Stairways and ramps

VII. Module 8: Building Features and Facilities (35 minutes)
   a. Customer service
   b. Plumbing facilities
   c. Other features

VIII. Module 2: Scoping and Other Codes (25 minutes)
   a. International Residential Code
   b. International Existing Building Code

Jay Woodward,
International Code Council

Jay is a Senior Staff Architect with ICC's Business and Product Development department and works out of the Lenexa, Kansas Distribution Center. His primary responsibility is the development of new ICC publications and instructing seminars. Among the publications he has authored or co-authored are the *Significant Changes* books on the IBC, IMC and A117.1 standard, and the recent ICC book *Firestopping, Joint Systems and Dampers*.

With over 30 years of experience in building design, construction, code enforcement and instruction, Jay's experience provides him with the ability to communicate effectively on issues of code application and design for code enforcement personnel as well as architects and designers. Jay has previously served as the secretariat for the ICC A117.1 standard committee, ICC's Energy Conservation Code and the *International Building Code's* Fire Safety Code Development committee.

2021 Accessibility and Usability for Commercial and Residential Buildings

Based on:
2021 International Building Code,
2021 International Existing Building Code and
ICC A117.1 - 2017 Accessible and Usable Buildings and Facilities

1

Accessibility in the Built Environment

7

Module 1

Introduction to Accessibility

- Scope and Technical Requirements of Accessibility Provisions.
- Coordination with Federal Documents.

9

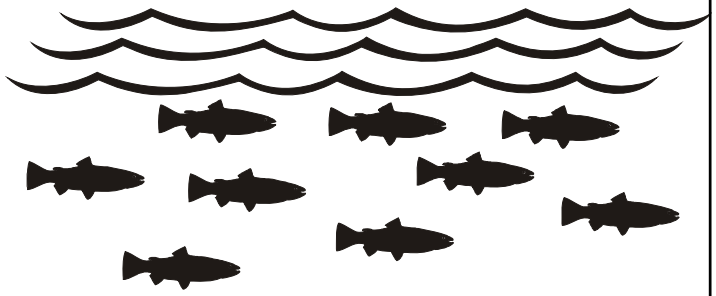
Requirements

- Scoping Requirements:
- "What, Where and How Many"
- (2021 IBC, IEBC, IRC)
- Technical Requirements:
- "How"
- (ICC/ANSI A117.1-2017)

11

Mainstreaming

Not all accessibility related requirements are in Chapter 11



12

Limitation of a referenced standards IBC Section 102.4

- Considered part of the code to the extent referenced
- Examples in A117.1 that are not referenced – stairways, Type C units, sign language interpreter's station
- Conflicts – codes rule

13

KEY LEARNING

2021 IBC - Philosophy 101

Everything must be accessible, and then allow for a degree of inaccessibility that is logical and reasonable.

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KEY LEARNING

Accessibility performance requirements - IBC

Section 1103.1

Everything must be accessible, and then allow for a degree of inaccessibility that is logical and reasonable.

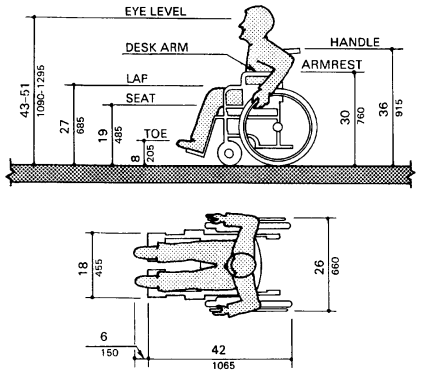
Section 1103.2

15

Basis for Technical Requirements

60

Dimensions of Adult-Sized Wheelchair



For SI: 1 inch = 25.4 mm.

61

2017 ICC A117.1

- Referenced for the first time in the 2021 IBC
- Revisions based on study on Anthropometry of Wheeled Mobility
  - Sponsored by the US Access Board
  - Including persons using manual wheelchairs, motorized wheelchairs & scooters
- http://idea.ap.buffalo.edu/projects/anthropometry/

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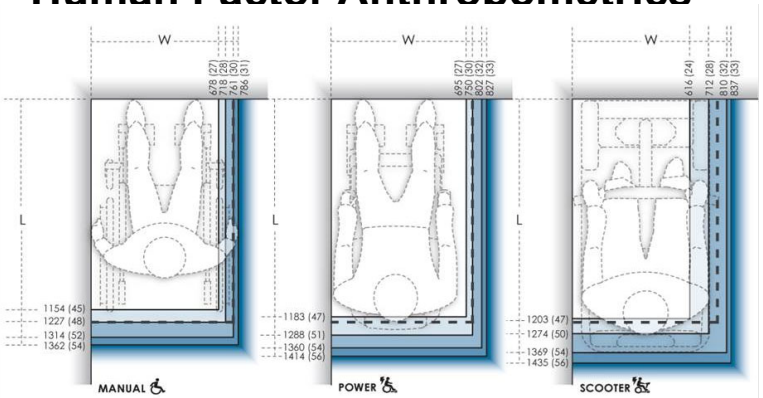
Human Factor Anthropometrics



67

2017 ICC A117.1

Revisions include items such as

- 30”x52” clear floor space
- 67” turning circle
- 8” chamfered corners on turns for 36” wide aisles and corridors
- Changes to turning spaces allowances to use knee and toe clearances
- Is referenced for the 1st time in the 2021 I-codes

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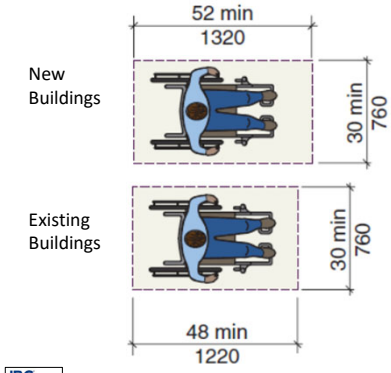
Clear Floor Space



- Length of space increased to 52” min. for new buildings
- 48” length for existing buildings
- This “building block” requirement impacts many provisions

76

Definitions – A117.1
Existing Building

- New definition
- Needed due to desire to lessen impact of 2017 changes
- Defined as “ A building erected prior to adoption of 2017 standard, or for which a legal building permit has been issued.”

77

Existing building and facilities

- New sizes will not apply to any alterations or change of occupancy in existing buildings or facilities, including the improvements to the accessible route
- New sizes will apply to new construction and additions

78

Module 3

Dwelling Units & Sleeping Units

- Institutional:
  - Groups I-1, I-2 and I-3.
- Residential:
  - Groups R-1, R-2, R-3 and R-4.
- Townhouses from IRC

79

KEY LEARNING

Accessibility performance requirements

- Transient and permanent housing should have units that can accommodate persons with mobility impairment's.
- Numbers are based on anticipated need for each type.
- Permanent housing should allow for aging in place, temporary impairments, and visiting.

80

Key Terms

- Dwelling unit:
  - Independent living facilities including provisions for living, sleeping, eating, cooking and sanitation.
- Sleeping unit:
  - Rooms where people sleep which may include living and eating and either cooking or sanitation.

81

Key Terms

- Dwelling or sleeping units, multistory.
  - Living space on more than one level.
- Intended to be occupied as a residence.
  - Dwelling units; or
  - Sleeping units; and
  - Occupant's place of abode.

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Shared Spaces

- All public spaces
- All spaces for shared use by residents
- Recreational facilities
- Parking:
  - 2% of parking provided
  - If covered parking provided, at least one accessible space in covered parking

2021 Accessibility Commercial and Residential

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Level of Accessibility

Accessible units:
- Constructed wheelchair accessible.
- ICC A117.1 Section 1102.

Type A units:
- Constructed wheelchair adaptable.
- ICC A117.1 Section 1103.

Type B units:
- Matches Fair Housing Accessibility Guidelines.
- Geared towards mobility impaired persons
- ICC A117.1 Section 1104.

2021 Accessibility Commercial and Residential 85

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Technical Criteria

110*.1 Type of unit;
110*.2 Primary entrance;
110*.3 Accessible route;
110*.4 Walking surfaces;
110*.5 Doors and doorways;
110*.6 Ramps;
110*.7 Elevators;

- 110*.8 Platform lifts;
- 110*.9 Operable parts;
- 110*.10 Laundry equipment;
- 110*.11 Bathing rooms;
- 110*.12 Kitchens;
- 110*.13 Windows; and
- 110*.14 Storage facilities.

2021 Accessibility Commercial and Residential 86

86

Existing Buildings

Accessible units and Type A units required based on number being altered.

Accessible and Type A units required shall not exceed new construction requirements.

Type B units are required when the alteration is to more than 50% of the building area (i.e., Level 3 alteration).

When Type B units are added, there are no extra requirements to improve the accessible route.

2021 Accessibility Commercial and Residential 87

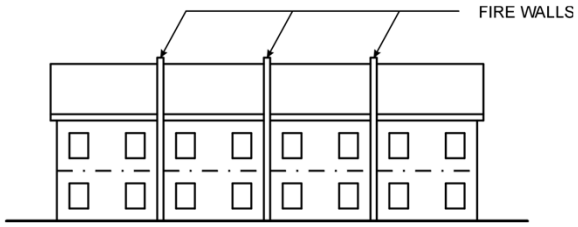
87

Counting Units

90

Fire Walls

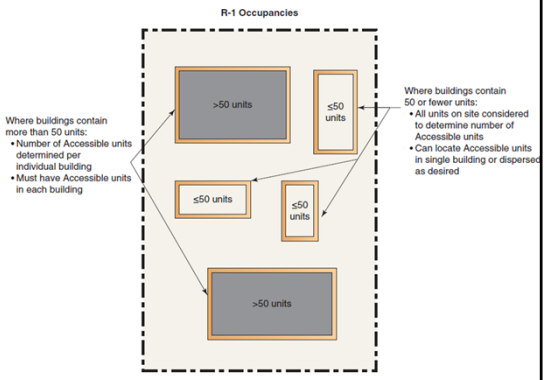
- This is one structure for purposes of accessibility.



91

Group R-1

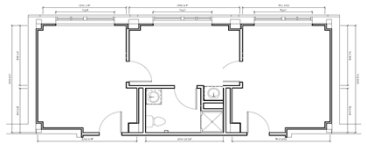
Determine the number of units on the site, and the number of Accessible units required



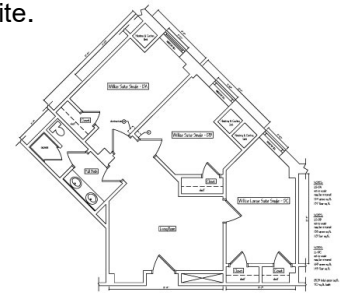
92

Group R-2 congregate residences and dormitories.

- Count the bedrooms in the suite to determine the number of Accessible units required.
- Only one Accessible unit per suite.



2 unit suite



3 unit suite

93

Institutional

94

Group I-1

- Condition 1 - 4% Accessible units.
  - ½ can use the assisted option for bathrooms
- Condition 2 -10% Accessible units
  - ½ can use the assisted option for bathrooms
- Remainder Type B units if intended to be occupied as a residence.
- Number of units with visible alarms per Table 907.5.2.3.2.

2021 Accessibility Commercial and Residential 96

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Group I-2– Hospitals

- 10% Accessible unit:
  - General purpose hospital
  - Psychiatric facilities
  - Detoxification facilities
- Remainder Type B units if intended to be occupied as a residence.

2021 Accessibility Commercial and Residential 97

97

Group I-2 – Nursing Homes

- 50% Accessible unit.
  - 90% of the 50% can use the assisted option for bathrooms
- Remainder Type B units if intended to be occupied as a residence.

2021 Accessibility Commercial and Residential 98

98

Group I-2 – Rehabilitation Facilities

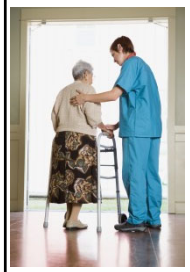
- 100% Accessible unit.
  - ½ can use the assisted option for bathrooms

99

Assisted toileting and bathing option

101

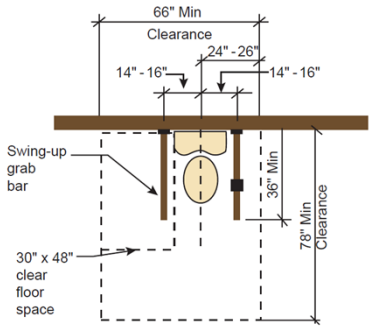
Assisted Toileting and Bathing



- Changes have been made to the provisions for nursing homes and assisted living facilities to allow some units to have toilet and bathing facilities designed for assisted use.
  - These allowances are permitted instead of the independent use facilities generally intended by the ICC A117.1 Accessible unit provisions.
- Both scoping and technical provisions are provided in IBC.
- The assisted use provisions are optional and can be applied when desired by the designer.
  - Units may be modified for toileting, bathing or both

102

Assisted Toileting



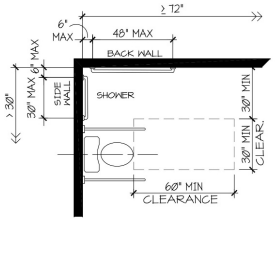
Primary technical changes include:

- Increased clearance around water closet of 66" with clearance of 24" to 26" from centerline of fixture
- Increased clearance depth of 78" to allow for additional approach options
- Allowance for swing-up grab bars that are typically only permitted in Type B units
- Toilet paper dispenser to be installed on at least one of the swing-up grab bars

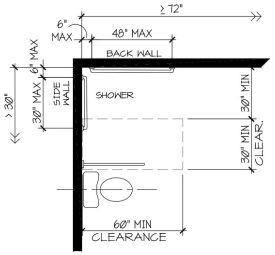
103

Assisted Bathing

- Primary technical change is elimination of required folding seat
- Allows for use of rolling chair when necessary
- Sidewall and backwall grab bars now differ, with side-wall bar required on 'seat wall' and both grab bars starting in corners



ASSISTED BATHING ROLL-IN SHOWER - USING EXCEPTIONS EXAMPLE 1



ASSISTED BATHING ROLL-IN SHOWER - USING EXCEPTIONS EXAMPLE 2

104

Residential

105

Group R-1

- Number of Accessible unit based on Table 1107.6.1.1.
  - New way to add up units on the site.
- Remainder Type B units if intended to be occupied as a residence.
  - Number of units with visible alarms per Table 907.5.2.3.2.

106

Group R-2

Live/work units

- All dwellings are Type B units
- The work areas must be accessible.

107

Group R-2

Boarding Houses
Dormitories
Fraternity and Sorority Houses

Number of Accessible unit based on Table 1107.6.1.1.

Remainder Type B units.

108

Group R-2 -

Apartments and Condominiums
Convents and Monasteries

2% Type A units.
- add up units on the site
- >20 units in the facility.

Remainder Type B units.

109

Group R-3

All Type B units

- IRC sends townhouse back to the IBC as Group R-3 for accessibility.

110

Group R-4

Condition 1 –
One Accessible unit.

Condition 2 –
Two Accessible units

Remainder Type B units

111

Residential Code

112

Residential Code – R320

- Townhouses with 4 or more units – back to IBC as Group R-3
- Live/work units
- Bed n Breakfast

113

Dwelling and Sleeping Unit Exceptions

114

Exceptions – Accessible Units

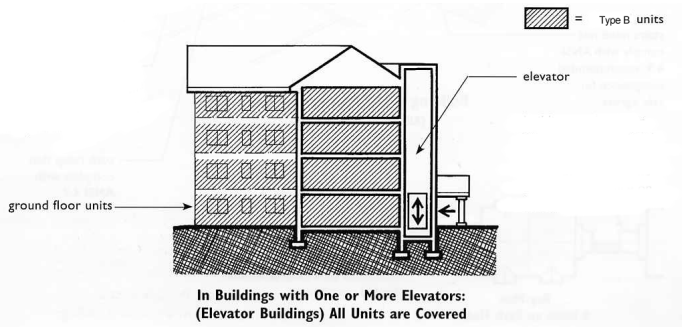
- No exceptions.

115

Exceptions – Type A and B Units

A B

- No exception for elevator buildings.



In Buildings with One or More Elevators:
(Elevator Buildings) All Units are Covered

116

Exceptions – Type A and B Units

A B

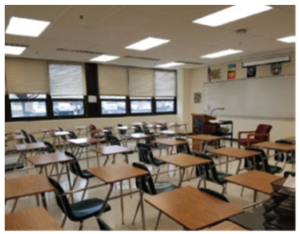
- Type A - <= 20 units in the site
- Type B - structures with less than 4 units.
- Non-elevator buildings.
- Multi-story units.
- Steep and hilly sites.
- Sites subject to flood regulations.

117

Classroom accoustics

156

Enhanced Acoustics for Classrooms (New)



- IBC 1207 & A117.1 808
- Provides guidance to improve acoustics by controlling:
  - Reverberation
  - Ambient sound levels
- Currently only for rooms ≤ 20,000 ft^3
- Helps improve hearing and comprehension/learning

157

Enhanced Acoustics for Classrooms (New)

Classroom Acoustics Requirements

Learning Space	Greatest one hour average sound level of exterior source background noise	Greatest one hour average sound level of interior source background noise	Maximum reverberation times for sound pressure levels in octave bands with frequencies of 500, 1000 and 2000 Hz.
Classrooms with an enclosed volume of <= 10,000 cubic feet	35 dBA/55 dBC	35 dBA/55 dBC	0.6 seconds
Classrooms with an enclosed volume of > 10,000 cubic feet and <= 20.000 cubic feet	35 dBA/55 dBC	35 dBA/55 dBC	0.7 seconds

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Module 5

Exterior Accessible Route

- Exterior Accessible Routes
- Parking Spaces
- Passenger Loading Zones
- Signage.

184

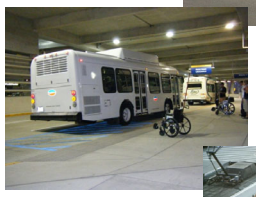
Accessibility performance requirements

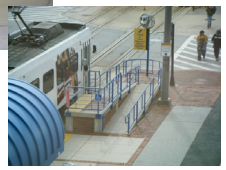
A person with mobility impairments should be able to arrive at the site, enter the building, and move throughout the building and site independently.

185

Public Arrival Points

- Accessible routes start at public arrival points such as:
  - Accessible parking spaces
  - Bus drop offs
  - Public transportation stops
  - Where a building sidewalk connects to the public sidewalk





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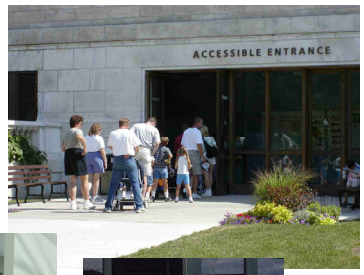
Accessible Entrances

- Accessible routes connection public arrival points to accessible entrances



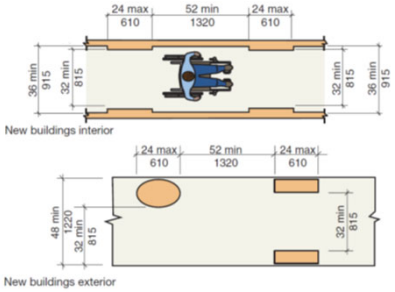
187

Other elements on the site

- Accessible routes are required to all facilities offered on the site.
- Exception: Where the only access is by a vehicular route, then the accessible route can also be provided by that vehicular route.

188

Walking Surfaces

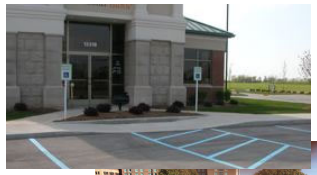


- Width of new exterior accessible routes increased to 48” min. (A117.1 403.5.1)
- Existing exterior routes can stay at 36” min. (IEBC 306.7.6)

189

Curb Ramps and Blended Transitions

- Three option:
  - Perpendicular curb ramps
  - Parallel curb ramps
  - Blended Transitions
- Working to coordinate with proposed federal PROWAG



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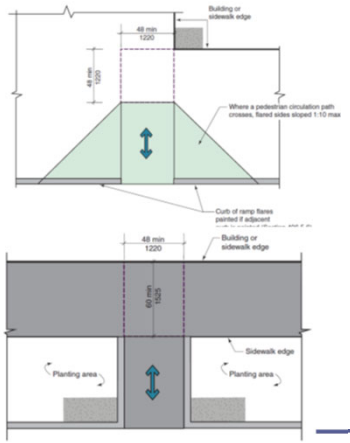
Perpendicular Curb Ramps

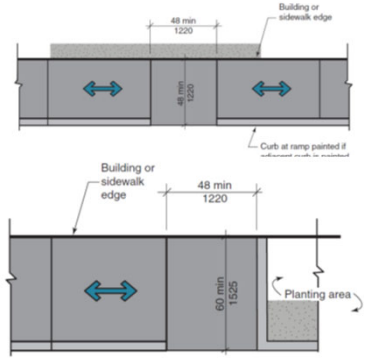


- 48” min. landing length at top; 60” min. if constrained
- Larger landing (width and length) allows for turning
- Requires flared sides if circulation path crosses ramp
- Limits slope of ramp to 1:20 min., 1:12 max. but does not require ramp >15 feet.

194

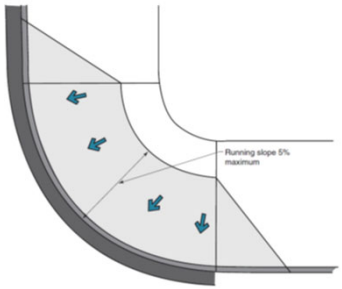
Parallel Curb Ramps

- Landing increased to 60” min. depth from street if constrained on two sides
- Limits slope of ramp to 1:20 min., 1:12 max. but does not require ramp >15 feet.



195

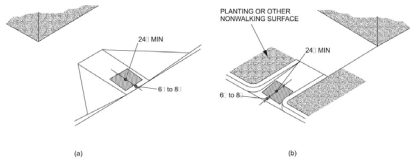
Blended Transitions



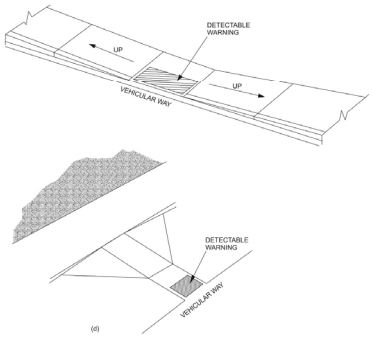
- Are not a curb “ramp” because slope ≤1:20
- Rely on “common requirements” for most provisions
- Previously inconsistent applications due to no specific details in standard

196

Detectable Warnings at Curb Ramps



- Detectable warnings are not required on curb ramps by IBC or A117.1
- If a designer chooses to provide detectable warnings, then technical provisions are provided for area covered, location, pattern and contrast.



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Accessible parking and passenger loading zones

202

Accessible Parking Spaces

- Based on number of parking spaces provided.
- Number of parking spaces required per zoning ordinances.
- Accessible spaces required:
  - Table 1106.1 for general parking.
  - 2% for Group R-2 and R-3.
  - 10% at hospitals facilities.
  - 20% at mobility treatment centers.
  - 1 of 6 accessible spaces sized for a van

203

Dispersion by Type

- Parking lots
- Parking garages
- Carports
- Private garages
- Pay/free
- Employee/visitor only



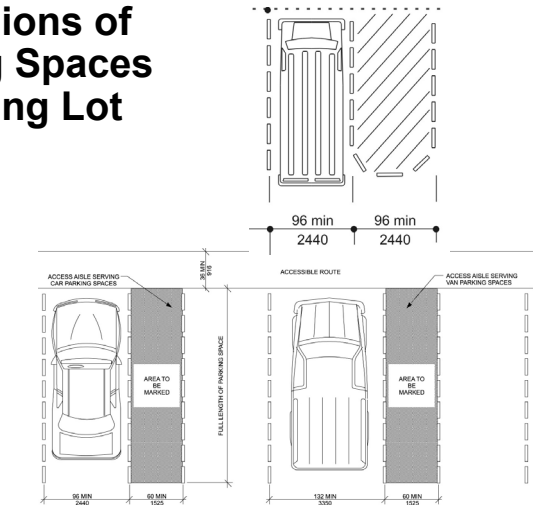

204

Parking Locations

- Locate on the shortest accessible route to an accessible entrance.
- Multi-entrance building or multi-building sites – disperse spaces
- Exception:
  - Van spaces on ground level of parking garages (vertical clearance of 98 inches)
  - Grouped where better access is provided

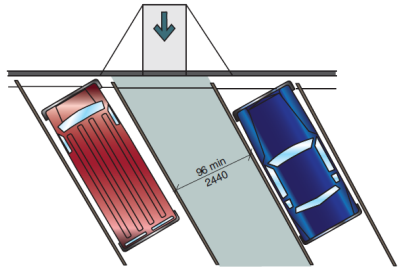

205

Dimensions of Parking Spaces in Parking Lot



206

On street parking



Perpendicular or angled parking

- Added provisions related to diagonal and parallel parking
- Allows slope with street
- On-street provisions based on and coordinate with PROWAG

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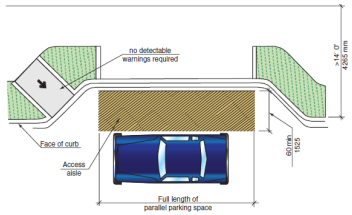
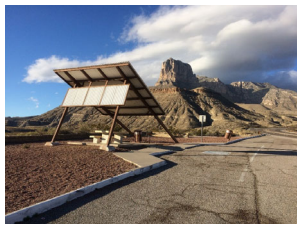
On street parking

- Parallel provisions depend on width of sidewalk or right-of-way
- Use “Wide” if >14 ft. width right-of-way, “Narrow” if ≤14 ft.



Parallel parking – Wide sidewalk



208

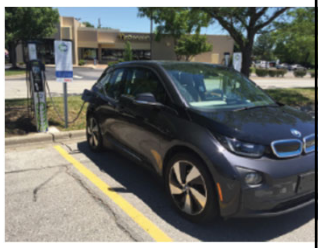
Parking Meters and Pay Stations

- Stations that serve accessible parking spaces
- Provisions added to address location and access to on-street parking meters and pay stations.
  - Not applicable to parking lots
- Done to coordinate with PROWAG
- Requires: Compliance with operable parts, location at end of stall, visible display at 40” max.

209

Electrical Vehicle Charging Station

- Ensures they are accessible and usable
- Regulated “where provided” at parking spaces
- Provisions address operable parts, accessible route, obstructions
- Applies to both parking lots and on-street parking



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Module 6

Accessible Entry vs. Accessible Exits

- Comparison of Requirements.
- Accessible Entrances.
- Accessible Means of Egress.
- Visible and Audible Alarms.

215

KEY LEARNING

Accessibility performance requirements

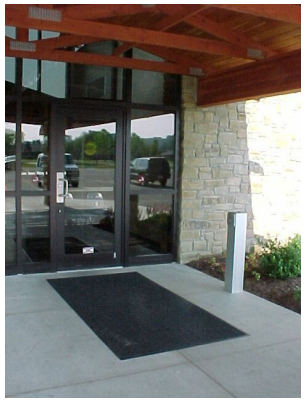
- A person with mobility impairments should be able move throughout the building independently.
- Evacuation may require assistance – so it is important to communicate between emergency responders and persons who need assistance.

216

Accessible Entry

218

Accessible Entrance



- Special entrances – at least one:
  - Parking garages
  - Tunnels
  - Elevated walkways
  - Restricted
  - Inmates or detainees
- Public entrances – 60%.
- Individual entrance
  - Tenants
  - Accessible Group I and R dwelling and sleeping units

219

Exceptions

- Areas not required to be accessible.
- Doors that serve as means of egress only.
- Service entrances that are not the only entrance to a tenant.

220

Automatic Doors at Public Entrances

- In specified occupancies with sizable occupant loads, the accessible public entrances must now be provided with an automatic door.
  - Where an automatic door is required by Table 1105.1.1, it shall be either a full power-operated door or a low-energy power-operated door.

TABLE 1105.1.1 Public Entrance with Power-Operated Door[a]

Occupancy	Building Occupant Load Greater Than
A-1, A-2, A-3, A-4	300
B, M, R-1	500

a. In mixed-use facilities where the total sum of the building occupant load is greater than those listed, the most restrictive building occupant load shall apply.

221

Automatic Doors at Public Entrances

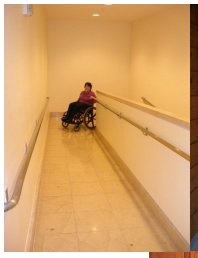
- In mixed-occupancy buildings where total building occupant load exceeds that listed, the most restrictive building occupant load shall apply.
- Where the public entrance includes a vestibule, at least one door into and one door out of the vestibule must comply with the requirements.
- **Very important to understand that doors that require card or key entry will most likely still be considered public entrances.**

222

Interior Routes

- Connect accessible entrances to accessible spaces within the building
- The accessible route must allow for unassisted access

Ramps



Horizontal surfaces

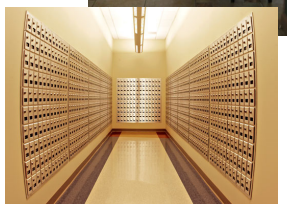
Platform lifts

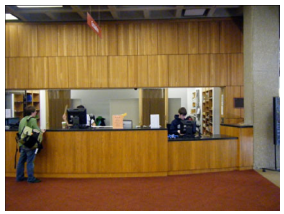
Elevator

223

Additional Routes

- Connections between dwelling and sleeping units and all shared facilities (e.g., dining halls, lobby, laundry, mailrooms).





224

Accessible Means of Egress

225

Accessible MOE

An accessible means of egress is:

- A continuous and unobstructed accessible route of egress travel from any accessible point in a building or facility to a public way.
- The intent – self-evacuation as much as possible – sometimes completed with assistance.

226

Accessible MOE Options

- Assisted rescue when necessary
- Defend in place (i.e., hospitals, jails)
- Assisted evacuation at stairways
- Assisted evacuation at elevators with standby power

227

Accessible Entry vs. Accessible Exit

TERM	DEFINITION	EXAMPLE	REQUIRED #
Accessible Entry	Consists of: •Exterior accessible route. •Accessible entrances. •Interior accessible route.	Elevator	60% of the entrances
Accessible Exit	Consists of: •Exit access via interior accessible route. •Area of refuge/Exit. •Exit discharge.	Exit Stairway	1 AMOE with 1 MOE 2 AMOE with 2+ MOE

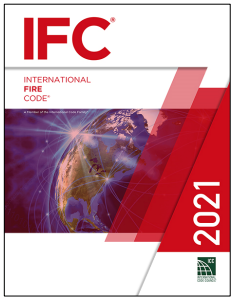
228

Planning

229

Pre-Planning for Emergencies

- Fire evacuation plans
- Fire safety plans
- Lockdown plans
- Associated drills
- Worked out with the building owner/renter and the fire department
- Updated annually or when necessitated by changes
- Available for review



230

Fire Evacuation Plans

- Emergency routes
- Strategy - Evacuation or defend in place
- Critical equipment operation
- Assisted rescue procedures
- Verifying full evacuation
- Emergency responders
- Notification of occupants
- Notification of fire department
- Emergency voice/alarm communication system

231

Fire Safety Plans

- Reporting emergency
- Evacuation or relocation of all occupants
- Site plans – occupancy assembly point, fire hydrants, fire truck route
- Floor plans – exits, routes, areas of refuge, fire alarm, extinguishers, fire hoses
- Major fire hazards
- Persons responsible

232

Emergency Drills

- Assembly – quarterly
- Business – annually
- Educational – monthly
- Factory – annually
- Institutional – quarterly on each shift
- Hotel - quarterly on each shift
- Apartments/dorms – 4 times annually
- Group homes - quarterly on each shift
- High rise - annually

233

Notification& Communication

234

Audible and Visible alarms

- Installed in accordance with NFPA 72.
- Manual fire alarm pull stations mus accessible.

235

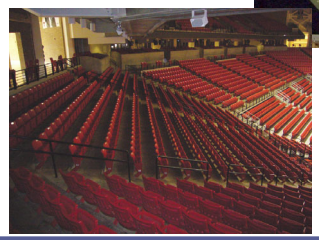
Visible Alarms

- All public spaces.
- All common spaces.
- Group I-1 (assisted living) and R-1 (hotel) units per Table 907.5.2.3.2.
- Future expansion for:
  - Individual employee work areas.
  - Smoke alarms in Group R-2 (apartments) units.

236

Notification & Communication

- Mass notification fire alarm signals in stadiums, arenas, and grandstands with more than 15,000 fixed seats now require captioned messages.



237

Exit Signs

- Visual exit signs at stairway entrances
- Tactile exit signs at stairway entrances, areas of refuge and exterior area for assisted rescue

239

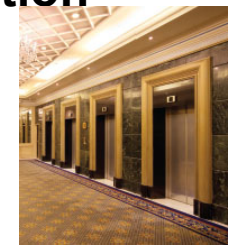
Stairway Signage

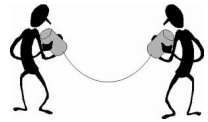
- Visual signage within the stairway
- Tactile signage indicating floor levels
- Tactile signage at the door leading to the exit discharge

240

Two-way Communication

- Within areas of refuge
- At elevator lobbies in sprinklered buildings (starting with 2009 IBC including when the elevator is not part of an AMOE)
- Variety of options
- Allow for communication and feedback between emergency responders and people who need assistance





241

Accessible Means of Egress Requirements

242

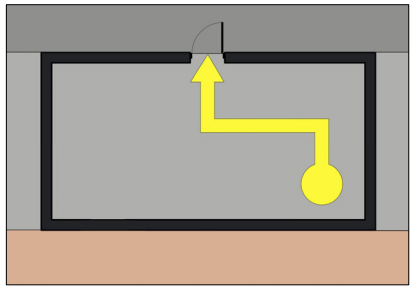
AMOE: Minimum Number

- Minimum number of AMOE required:
  - 1 AMOE - where 1 MOE required
  - 2 AMOE - if more than 1 MOE required
- Exceptions:
  - Existing facilities
  - Areas that are not accessible
- Must consider both the building and spaces within the building.

243

Example: 1 MOE/AMOE

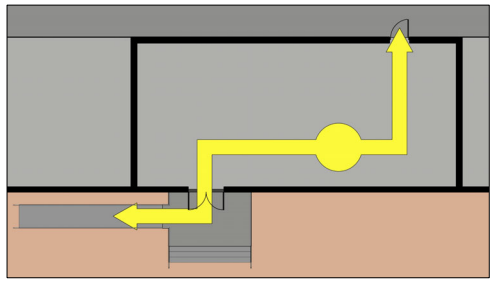
- 1 MOE & 1 AMOE allowed under these conditions:
  - mercantile occupancy; and
  - 49 or fewer occupants; and
  - 75’ max. travel distance from farthest point



244

MOE: Minimum Number

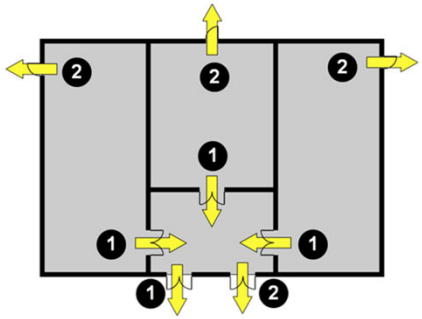
- At least 2 MOE required



245

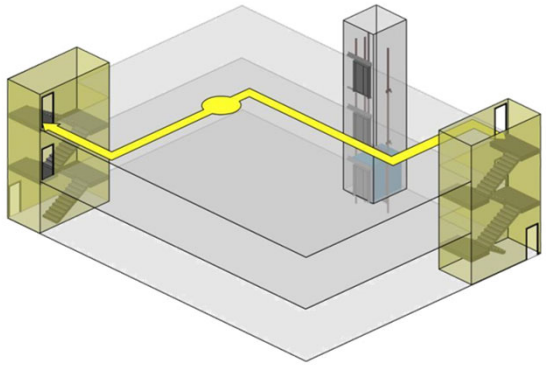
MOE: Minimum Number (cont)

- MOE required from each space and room



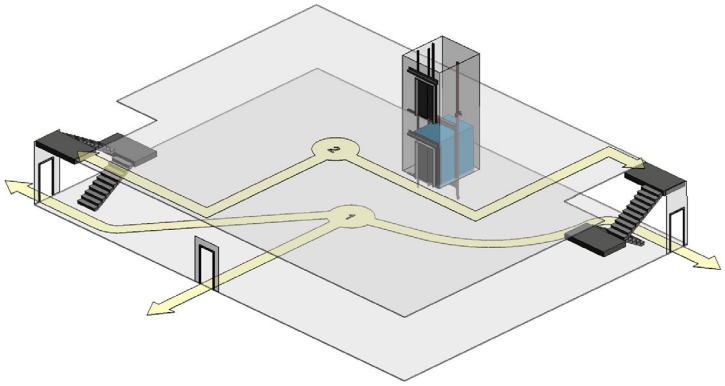
246

Exit Access: Upper Floors



247

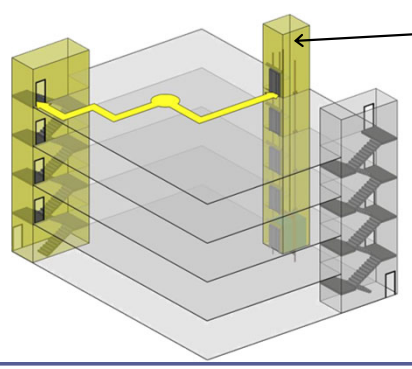
Exit Access – Open Stairs



248

Elevator with Standby Power

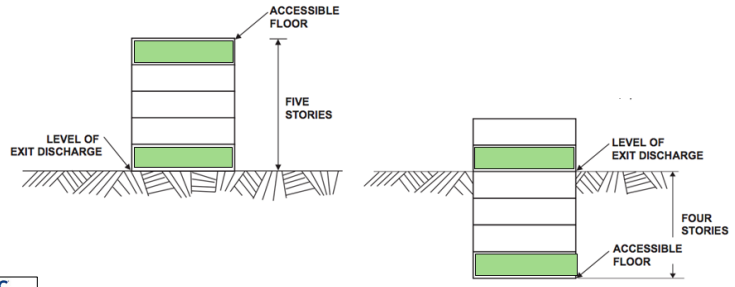
- Required in buildings 5 stories or higher



249

Elevator with standby power - Determining stories

- Required in buildings with 4 or more stories above or below the level of exit discharge



250

Exit Discharge

Only at the level of exit discharge

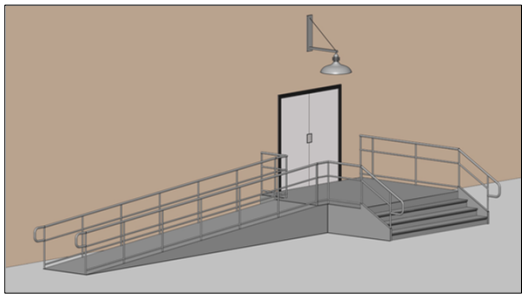
- Accessible route to a public way or
- Interior area of refuge or
- Exterior area for assisted rescue

No exceptions for sprinklered buildings

254

Exit Discharge – Option 1

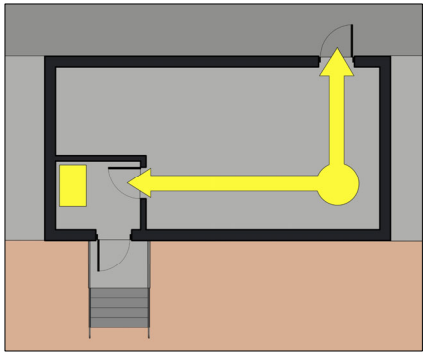
- Accessible route to a public way



255

Exit Discharge – Option 2

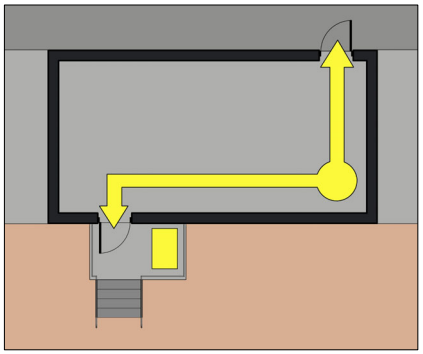
- Interior Area of Refuge



256

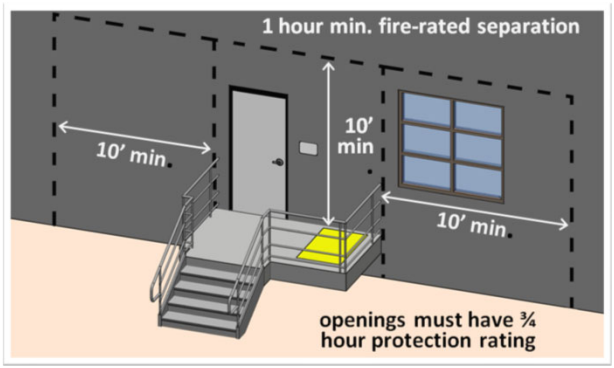
Exit Discharge – Option 3

- Exterior Area for Assisted Rescue



257

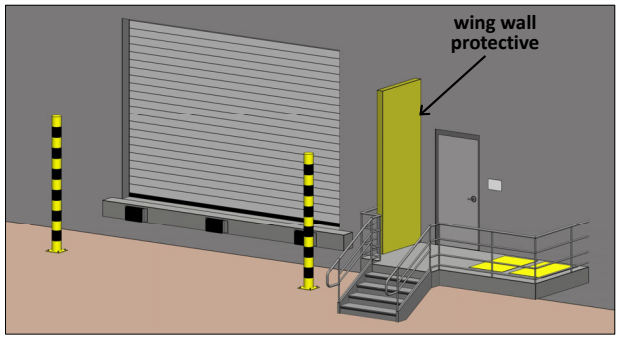
Exterior Area for Assisted Rescue



2018 IBC Rated wall is not required in sprinklered buildings

258

Exterior Area for Assisted Rescue – Wing wall option

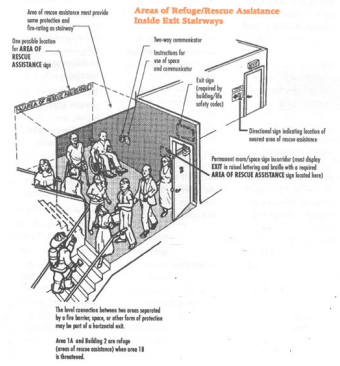


259

Area of refuge in non-sprinklered buildings.

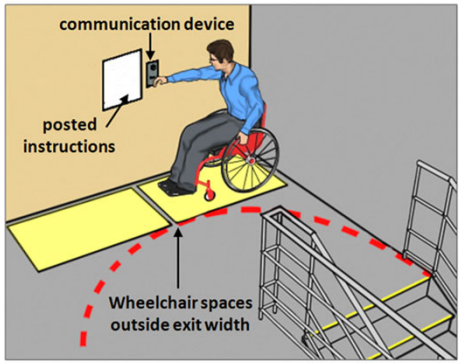
Technical criteria:

- On accessible route
- Separated by a smoke barrier
- Direct access to exit stairway, elevator with standby power
- Alternative: horizontal exit



260

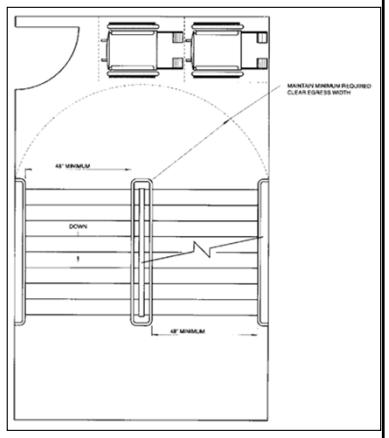
Areas of Refuge - Example



261

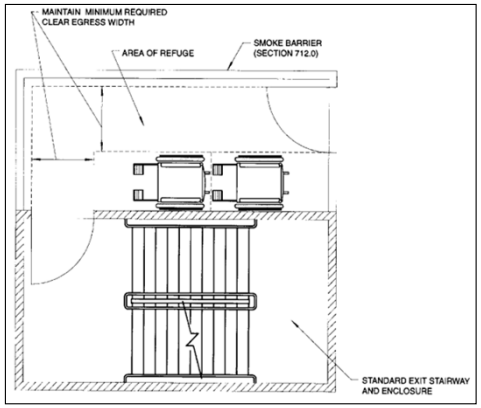
Areas of Refuge – Inside stairway

- 48” min. stairway width (between handrails)
- 30” x 48” space (1 for every 200 occupants) located outside general MOE path
- Two-way communication system
- Identification and instructional signage



262

Areas of Refuge – adjacent to stairway



263

Areas of Refuge - exceptions

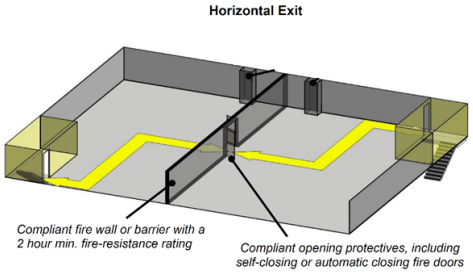
Exceptions for areas of refuge:

- buildings fully equipped with an automatic sprinkler system
- open parking garages
- open exit access stairways between stories

264

Horizontal exit exception

- A horizontal exit allows for slower evacuation of the building
- Alternative for areas of refuge
- Standby power not required at elevators where this is on all floors but the level of exit discharge



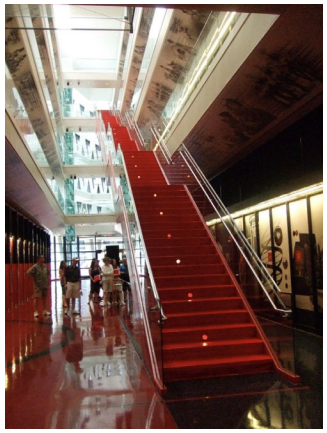
265

Special consideration

266

Open stairways

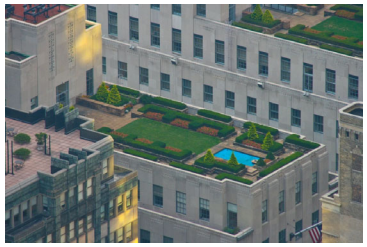
- Open stairway can be supplemental or part of a required MOE
- Open stairways for required MOE is mostly for two story buildings and with travel distance limitations (there are limited exceptions)
- Open stairways that are part of the required MOE can also serve as AMOE
- No area of refuge, even in non-sprinklered buildings
- Two-way communication at the elevator



268

Occupied roofs

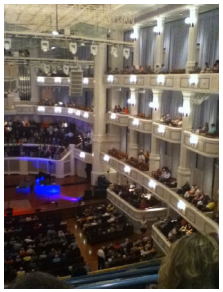
- Treated the same as a story for an accessible route and means of egress
- Occupied roof same as floor for AMOE
- Specifically indicated in 2021 IBC as a story for requiring elevators with standby power.



269

Assembly seating

- Two ways out for every wheelchair space location
- Common path of travel for how far you can go back out the way you came in before you have two ways to go



271

Module 7

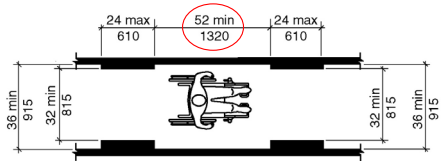
Interior Accessible Route Elements

- Technical requirements.
- Doors.
- Elevators and Platform Lifts.
- Stairways and Ramps.

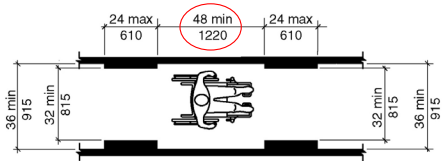
275

Minimum Clear Width for Single Wheelchair

New

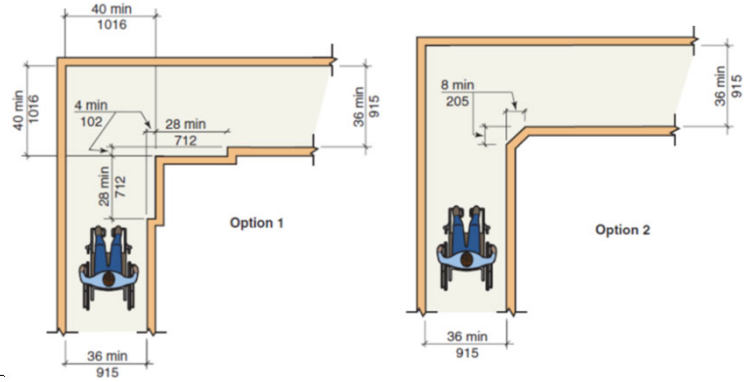


Existing



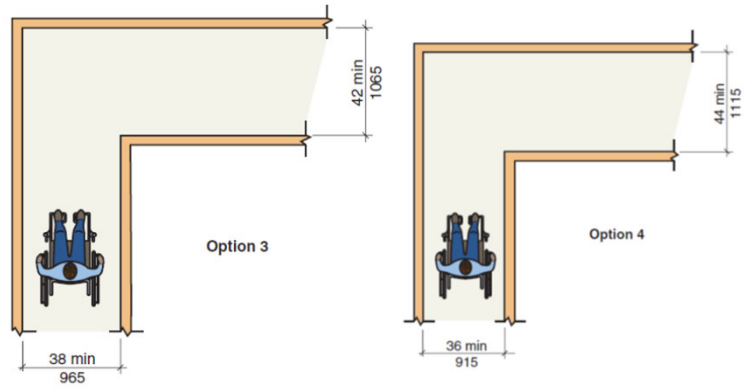
276

At 90-degree Turn (New)



277

At 90-degree Turn (New)



278

At 90-degree Turn (New)

- New buildings have four options for making turns on 36” wide accessible routes
- Exceptions exempt turns at doors, elevators, platform lifts
- Does not include turns into clear floor spaces at fixtures, elements or wheelchair spaces.

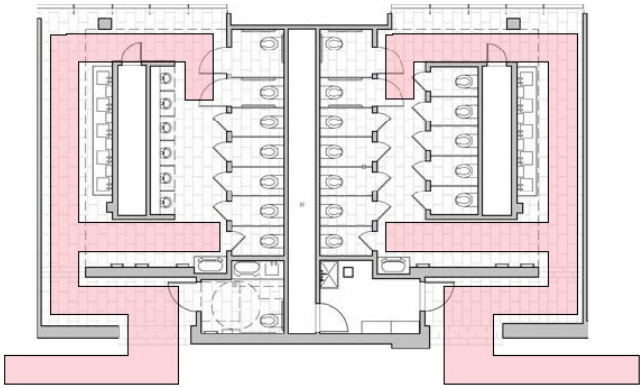
279

At 90-degree Turn (Existing)

- Existing buildings may continue to use a 36" route at 90-degree turns
- 2009 Standard did not have a section for 90-degree turns but used general route requirements.
- Existing building provision match with ADA

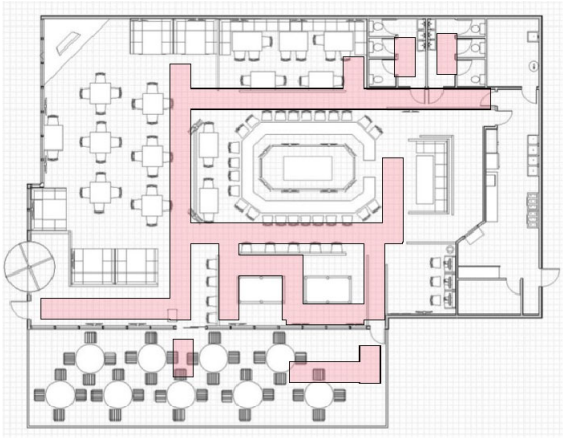
280

Impact - Multi-stall layout



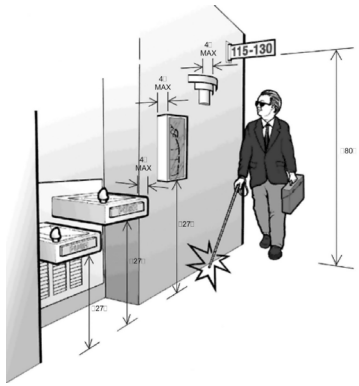
281

Impact - Dining room layout



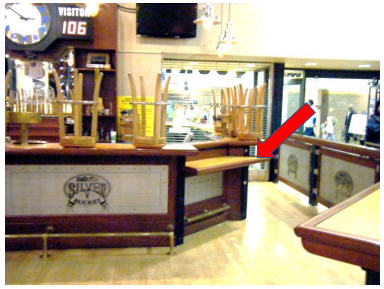
282

Protruding Objects Along A Circulation Path



283

Protruding object



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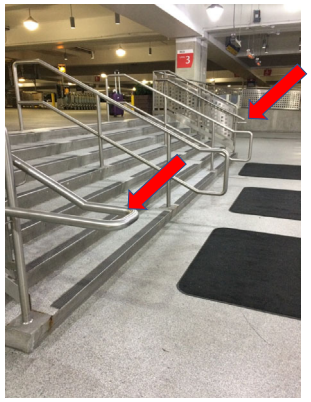
Protruding object



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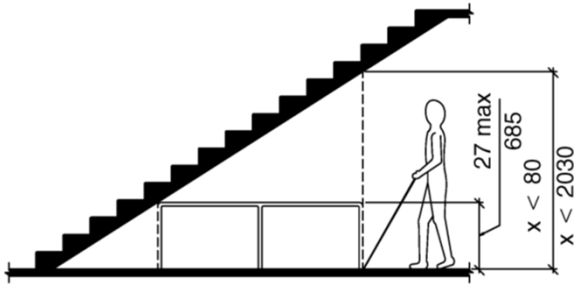
Overhead Protruding Objects



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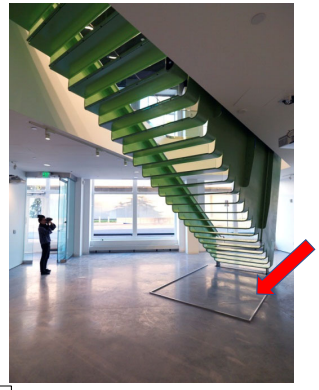
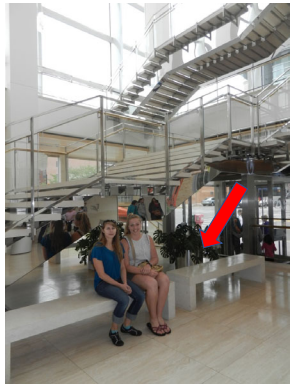
Overhead protruding object





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Doors

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Doors

Doors Operation
1010.1.8

Door Size
1010.1.1

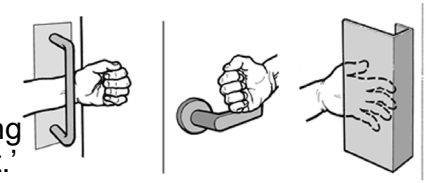
Doors in a Series
1010.1.9

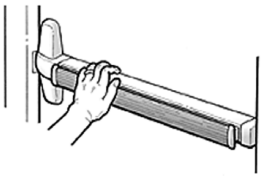
Door Swing
1010.1.2

290

Hardware

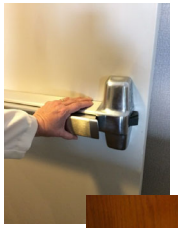
- Examples of 'no tight pinching, tight grasping or twisting of the wrist.'
- Hardware height is between 34" and 48"
- 5 lbs. force it to open the door after the latch has been disengaged.

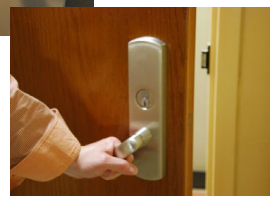




291

Manual Doors and Gates
Hardware & Opening Force





- Splits provisions for hardware and door forces
- Provides operational force for hardware
  - 15 pound forward pushing or pulling
  - 28 inch-pounds rotational motion

292

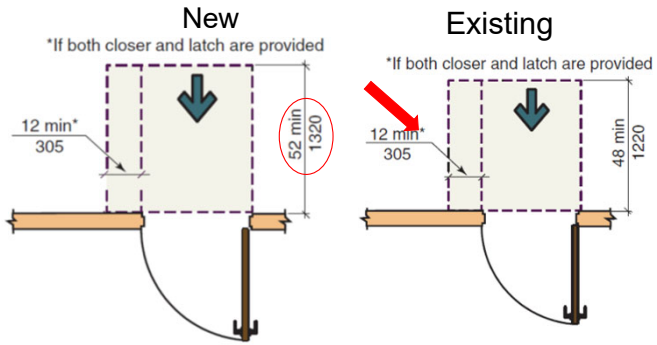
Door Surface

- On the push side, the bottom 10” must be clear of obstructions

293

Manual Doors and Gates
Maneuvering Clearances

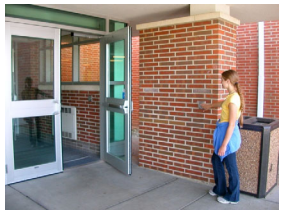
Required at manual doors where someone moves through the door as part of an accessible route.



294

Maneuvering Clearance – Automatic doors

- Required at power assist doors
- Not required a low-power automatic doors and fully automatic doors unless part of AMOE
- Options for standby-power, battery backup, open with power off, or break away



296

Stairways and Ramps

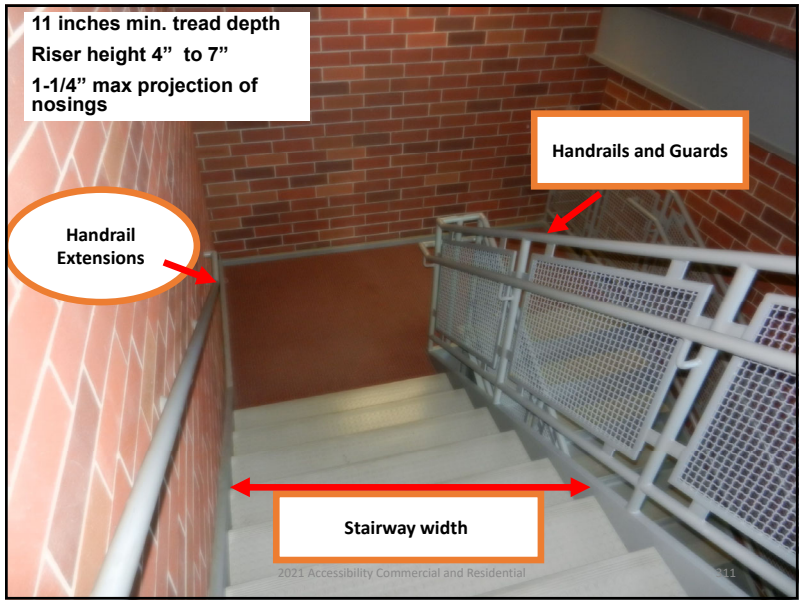
309

303

Stairways

- Not part of the accessible route into building.
- Part of an accessible means of egress out of building with assistance.
- Mainstreamed requirements with no reference to ICC A117.1.
- Safety provisions for persons with mobility and visually impairments addressed in IBC.

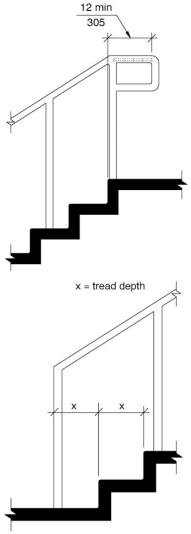
310



311

Handrail Extension

- The handrail extension a the bottom is 1 tread depth minimum and sloped.
- The 2010 ADA has removed the requirement for the additional 12" horizontal extension at the bottom.
- The handrail extension at the top is 12" minimum horizontal.
- The extension must be in the direction of the stairway run



312

Solid tread and risers?

- Treads allow for opening ½" or smaller
- Risers should not allow for someone to get their foot caught under the tread.

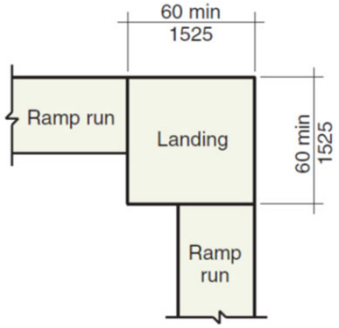
313

Ramp Technical Criteria

- >1:20 slope.
- 1:12 slope maximum on accessible routes.
- Change in level at start of ramp
- Surfaces – slip resistant
- Cross slope - < 1:48
- Minimum width – 36” between handrails
- Maximum rise – 30” between landings
- Adequate landings

314

Ramps



- Requires 60” x 60” landing at change of direction – not “turning space”
- Exception reduces ramp width due to equipment in employee work areas

315

Module 8

Building Features and Facilities

- Customer Service.
- Plumbing Facilities.
- Other Features.

321

Customer Service

322

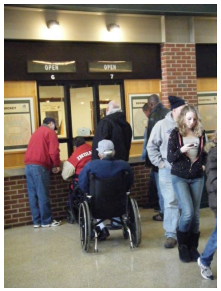
Built-in Counters

- Check out aisles.
  - Table 1110.13.1 based on number provided.
- Sales and service counters.
  - At least on of each type.

323

Sales/Service Counters & Windows

- "Windows" added into requirements
- Regulates "public portion" "where counters are provided"
- Employee side is not regulated since it is a work area
- Clarifies small (<36" length) parallel counters are OK if that is entire counter length



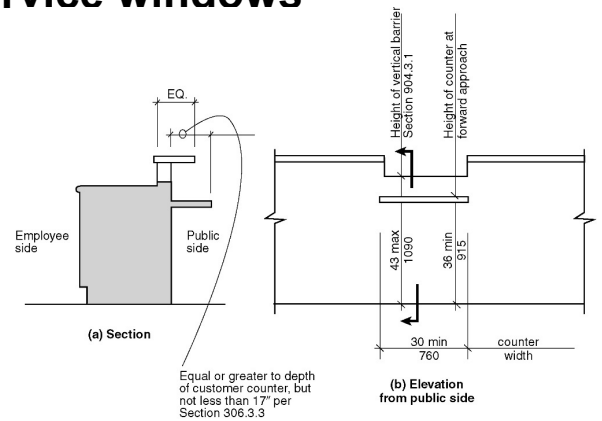
326

Sales/Service Counters & Windows

- Side or front approach
- Equal customer counter
- Maximum barrier height to allow for face-to-face contact between employee and customer
- Allowance for security windows

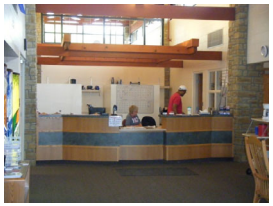
327

Service windows



328

Sales and Service Counters–




329

Mailboxes – Good or Bad?

341

Plumbing Facilities

342

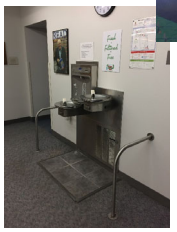
Drinking Fountains (Scoping)

- 50% of drinking fountains provided on each floor configured for persons using wheelchairs.
- 50% of drinking fountains provided on each floor configured for standing persons.
- Exception for drinking fountains sized for children

343

Drinking Fountains (Technical)

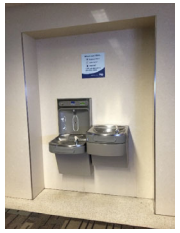
- Clear floor space/approach
- Protruding objects
- Operable parts
- Spout location
- Water flow



344

Bottle Filling Stations

- Water bottle-filling stations, where provided, are to be accessible.
  - Stations located over drinking fountains for standing persons not required to be accessible, provided such stations are also located over the drinking fountains for persons using wheelchairs.
- Technical requirements found in A117.1 Section 602.4.
  - Clear floor space provided for either a forward or side approach
  - Controls to comply with operable parts requirements



345

Toilet rooms

- Required fixtures per IPC.
- Designers choice for how required fixtures are separated:
  - Multi-stall toilet rooms
  - Single occupant toilet rooms
- All toilet rooms must be accessible per Chapter 6 of ICC A117.1.

346

Exceptions

- Accessed through a private office.
- Non-accessible dwelling or sleeping units.
- 50% of each type of clustered single occupant toilet rooms.
- When only one urinal is provided in a toilet room, that urinal is not required to be accessible.
- Critical care or Intensive care.
- Allowance to design for children

348

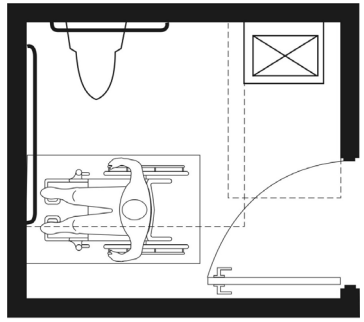
Toilet and bathing rooms

- One of each type of fixture provided in each toilet or bathin room:
  - Water closets
  - Lavatories
  - Urinals
  - Bathtubs/Showers
- When 6 or more water closets and/or urinals are provided in a room, an ambulatory stall is required.

349

Single Occupant Toilet Rooms

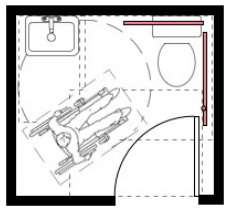
- 60” turning space required in the room
- A door **can** swing over the space where someone sits to use the lavatory, toilet or urinal **provided** a 30” x 48” space is provided past the swing of the door
- A fixture **cannot** overlap the clear floor space of another fixture

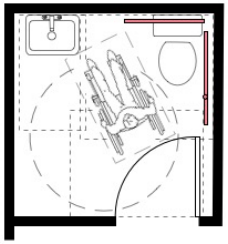


359

Impact – Single occupant toilet room design

- Existing
- New

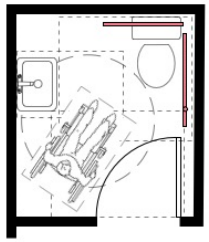


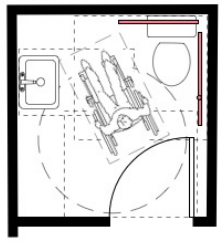


360

Impact – Single occupant toilet room design

- Existing
- New

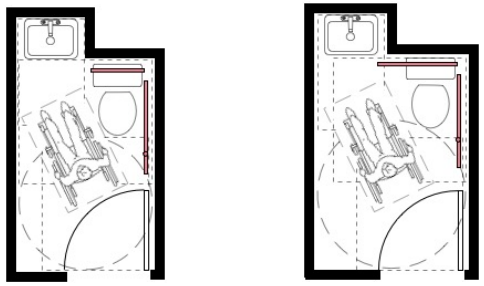




361

Impact – Single occupant toilet room design

- Existing
- New



2021 Accessibility Commercial and Residential 362

362

Other features

2021 Accessibility Commercial and Residential 383

383

Operable Parts

- All operable parts within accessible spaces and intended for occupant usage.

2021 Accessibility Commercial and Residential 384

384

Operable Parts

- A117.1 Section 309.1 is now referenced regarding those operable parts exempted from accessibility, allowing for the deletion of like exceptions in IBC.
- Five exceptions deleted from IBC to:
  - Eliminate redundancy and confusion
  - Maintain consistency between ICC A117.1 and IBC
- Exceptions addressed include:
  - One kitchen counter top outlet where two or more provided
  - One control, for other than light switches, where redundant controls are provided
  - Electrical receptacles serving dedicated use
  - Floor electrical receptacles
  - HVAC diffusers

2021 Accessibility Commercial and Residential 386

386

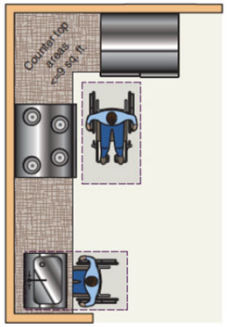
Operable Parts
309.1, 1102.9, 1103.9

- Exceptions for operable parts moved from Chapter 11 to Section 309
- Allows exceptions to be used for all public areas and not just in the dwelling units
- Eliminates exceptions in Accessible and Type A units
- Primary changes are:
  - New exception 3 and 10

387

Operable Parts
309.1, 1102.9, 1103.9

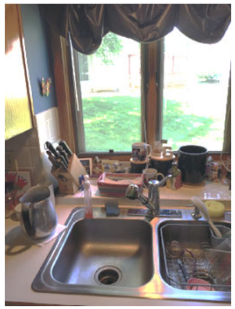
- Exception 3 covers outlets in kitchen. Limits include:
  - Location where parallel approach cannot be provided
  - Outlets are over counter in a corner
  - Excluded area < 9 sq. ft. in area
  - Excluded area is "between appliances"
- Exception 10 is for emergency devices used by emergency personnel, during emergencies



388

Windows

- Separate force provisions for latch or operable parts versus window opening force
- Four forces on a required window – locking, unlocking, opening and closing
  - Locking/unlocking are operable parts
  - Opening/closing - *AAMA 513*



390

Windows

Operating force for opening/closing windows:

- 8.5 pounds max. for vertical or horizontal sliding
- 5 pounds max. for all other types

- Type A units only regulate height and clear floor space
- Accessible and Type A units exempt windows in kitchens and bathrooms
- Not required in Type B units

391

Existing buildings

393

Accessibility performance requirements

- This is not mandatory retrofit
- Existing buildings are improved as you alter, with the idea that they will become as accessible over time as technically feasible.
- Whatever you touch, you fix.
- As long as you are making alterations, this is the best time to make improvements to the accessible route, bathrooms and drinking fountains that serve the area being altered.

394

Existing Buildings

- Maintenance.
- Alteration.
- Change of occupancy.
- Addition.
- Historic buildings.

395

Which book to use?

- Chapter 34 was deleted from the 2015 IBC
- The 2021 IEBC has three methods–
  - Prescriptive Compliance Method – Chapter 5
  - Work Area Method – Chapters 6 through 12
  - Performance compliance method – Chapter 13
- Accessibility provisions for all three methods in Section 306

396

Maintenance & Repair

A facility that is constructed accessible must be maintained accessible.

397

Extent of Application

Alterations are not required to exceed the accessibility that would be required for a new building.

398

Additions

- Additions must comply with new construction.
- If the addition relies on the toilet rooms or route through the existing building for access into the space, then the same accessible route provisions for alterations would apply.

399

Alterations or COO to Existing Buildings – Part 1

- Change of occupancy and alterations treated the same for improvements for accessibility.
- When altering an existing building, everything that is altered must meet requirements for accessibility.

400

General Exceptions

- Accessible means of egress not required to be added.
- Technically infeasible.
- When historical significance is adversely affected.
- Type B units when the alteration is to less than 50% of the area of the building (Level 1 or 2)

401

Technically Infeasible

- Removal or *alteration* of a load-bearing member that is an essential part of the structural frame
- Existing physical or site constraints

402

Alterations to Existing Buildings – Part 2

- If the area being altered contains a primary function area, the route to that area and any toilet rooms or drinking fountains that serve that area must be evaluated for accessibility.
- If they are not accessible, additional improvements are required.

403

Primary Function Area

- A major activity for which the facility is intended.
- Excluding areas such as:
  - Mechanical room or boiler room
  - Supply storage
  - Employee lounge or locker room
  - Janitors closet
  - Entrances
  - Corridors
  - Restrooms

404

Accessible Route Exceptions

- The cost of the accessible route exceeds 20% of the cost of the alteration.
- The alteration is limited to items that will not alter the physical configuration or use of the space.
- The alteration is to improve accessibility.
- The route is to Type B units only.

405

Technical Assistance

- ICC and A117.1 – ICC, (888)422-7233; www.iccsafe.org.
- ADA – Access Board, 800-872-2253(v), 800-993-2822(TTY), www.access-board.gov or email at ta@access-board.gov
- ADA – ADA Technical Assistance Centers (800)949-4232; www.adata.org
- Fair Housing – Fair Housing Accessibility First, (888)341-7781; www.fairhousingfirst.org.

406

Thank you for attending.

Questions?

407

IACET Accreditation

- The International Code Council has been accredited as an Authorized Provider by the International Association for Continuing Education and Training (IACET).
  - As a result of their Authorized Provider accreditation status, ICC is authorized to offer IACET CEUs for its programs that qualify under the ANSI/IACET Standard.
- You will obtain full CEUs for this course, if you actively participate in the training activities and stay for the entire session. Evidence of this will be the sign out sheet.

409

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This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

410

410

Copyright Materials

411

411

Thank you for participating!

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1-888-ICC-SAFE (422-7233) Ext. 33821
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E-mail: learn@iccsafe.org
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412

412

File Attachments for Item:

EC-2 2021 IBC Fire-Resistance-Rated Walls (ICC)

All certifications (4 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 IBC Fire-Resistance-Rated Walls

Course instructor: Jay Woodward

Course description: This session discusses the application of IBC Chapter 7 related to the construction and protection of rated walls. The topics covered include identifying the five types of walls and their differences, including construction, continuity, marking and identification, as well as the protection requirements for penetrations, joint systems, ducts and air transfer openings, door and window openings. Additional discussion will look at the test standards used to evaluate the wall and protection systems, how to calculate the fire resistance for existing walls or archaic assemblies and the requirements for walls which serve multiple purposes.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: May 2, 2023 / Tampa Bay, FL

Special Content:

Code Administration:_____

Existing Buildings: _____

Electrical Instruction: _____

Plumbing Instruction:_____

Conference Course: 2021 IBC Fire-Resistance-Rated Walls

Conference Name: ICC Spring Interchange

Conference location: Tampa Bay, FL

Course to be offered online? N/A **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2021 IBC Fire-Resistance-Rated Walls

Description

This session discusses the application of IBC Chapter 7 related to the construction and protection of rated walls. The topics covered include identifying the five types of walls and their differences, including construction, continuity, marking and identification, as well as the protection requirements for penetrations, joint systems, ducts and air transfer openings, door and window openings. Additional discussion will look at the test standards used to evaluate the wall and protection systems, how to calculate the fire resistance for existing walls or archaic assemblies and the requirements for walls which serve multiple purposes.

Learning Objectives

Upon completion of this training participants will be better able to:

- Apply Chapter 7 related to the construction and protection of rated walls.
- Identify the five types of walls and their differences, including construction, continuity, marking and identification, as well as the protection requirements for penetrations, joint systems, ducts and air transfer openings, door and window openings.
- Describe the test standards used to evaluate the wall and protection systems.
- Calculate the fire resistance for existing walls or archaic assemblies.
- Identify requirements for walls which serve multiple purposes.

Outline: 4-hours = 240 minutes

1. INTRODUCTION (50 minutes)
    a. Fire Dynamics and the fire test standards
    b. Alternative method of determining fire resistance
    c. Purpose of fire-resistance-rated assemblies and fire-protection-rated assemblies
    d. Different types of fire-resistance-rated assemblies
    e. Different types of fire-protection-rated assemblies
    f. Definitions and terms
    g. Alternate methods and materials/engineering judgments
    h. Harmathy's Ten Rules and archaic assemblies
    i. Multiple use fire assemblies
2. TYPES OF RATED WALLS (30 minutes)
    a. Identify the five types of walls and their use

b. Differences between the various wall types
c. Marking and identification requirements for rated walls

3. COMPLETING THE PROTECTION
    a. Penetrations (30 minutes)
        i. Through and membrane penetration systems
        ii. Testing of firestop systems
        iii. F, T and L ratings
        iv. Generic/prescriptive methods
        v. Special Inspections
    b. Fire-resistant Joint Systems (20 minutes)
        i. Joints in and between rated assemblies
        ii. Perimeter fire containment systems
    c. Opening Protectives (30 minutes)
        i. Differences in various fire tests for doors and windows
        ii. Fire-resistance rated glazing
        iii. Fire door assemblies (what is required where and why)
        iv. Fire protection rated glazing (glazing in fire windows)
    d. Ducts and Air Transfer Openings (70 minutes)
        i. Identify the types of dampers
        ii. Describe the uses of fire and smoke dampers
        iii. Required location of fire and smoke dampers per codes
        iv. Importance of manufacturer's instructions
        v. Damper access requirements
        vi. Damper actuation
        vii. Testing organizations
        viii. Smoke damper ratings
        ix. Combination fire and smoke dampers
        x. Breakaways
        xi. Common damper mistakes
4. Conclusion (10 minutes)

Jay Woodward,
International Code Council

Jay is a Senior Staff Architect with ICC's Business and Product Development department and works out of the Lenexa, Kansas Distribution Center. His primary responsibility is the development of new ICC publications and instructing seminars. Among the publications he has authored or co-authored are the *Significant Changes* books on the IBC, IMC and A117.1 standard, and the recent ICC book *Firestopping, Joint Systems and Dampers*.

With over 30 years of experience in building design, construction, code enforcement and instruction, Jay's experience provides him with the ability to communicate effectively on issues of code application and design for code enforcement personnel as well as architects and designers. Jay has previously served as the secretariat for the ICC A117.1 standard committee, ICC's Energy Conservation Code and the *International Building Code's* Fire Safety Code Development committee.

2021 IBC Inspection of Fire-Resistance-Rated Walls

Based on the 2021 International Building Code®

1

Class Outline

- Introduction:
  - Determining fire resistance.
  - Test standards.
  - Definitions.
  - Alternate methods
- Type of Rated Walls:
  - Five types of walls and their use.
  - Differences between the various wall types.
  - Marking and identification requirements.

2

Class Outline (continued)

- Completing the protection:
  - Penetrations.
  - Joint systems.
  - Opening protectives.
  - Ducts and air transfer openings.

Fire side

Hotel side

3

Introduction

- Standard fire test methods for determining fire-resistance ratings and combustibility of materials are covered in Section 703.

4

Section 703.2 – Fire-resistance

- The fire-resistance ratings of building elements shall be determined in accordance with:
  - Section 703.2 – Tested assemblies
    - ASTM E119, or
    - UL 263
  - Section 703.2.2 – Analytical methods
    - Designs documented in approved sources
    - Prescriptive designs
    - Calculations
    - Engineering analysis
    - Designs certified by an approved agency
  - Section 703.2.3 – Approved alternative methods
    - As established by Section 104.11

5

Section 703.2.1 – Fire-resistance Ratings

The fire-resistance ratings of building elements, components and assemblies as determined by testing is to be in accordance with the procedures set forth in:

- ASTM E119 (*Test Methods of Fire Tests of Building Construction and Materials*), or
- UL 263 (*Fire Test of Building Construction and Materials*)

6

Purpose of Rated Assemblies

Fire Resistance: That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.

Fire-Resistance Rating: The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.

7

Purpose of Rated Assemblies

Fire Protection Rating: The period of time that an opening protective will maintain the ability to confine a fire as determined by tests prescribed in Section 716. Ratings are stated in hours or minutes.

8

Section 703.2.1.4 – Supplemental Features

- Where materials, systems or devices that have not been tested as part of a fire-resistance-rated assembly are incorporated into the assembly, sufficient data must show that the required fire-resistance rating is not reduced.
  - Materials and methods of construction used to protect joints and penetrations shall not reduce the required fire-resistance rating. (testing per 714 and 715 accomplishes this)

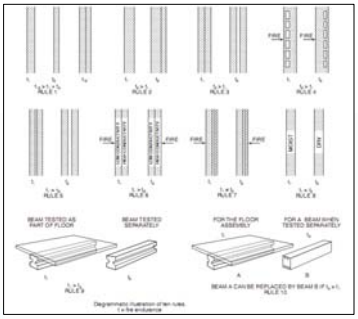
9

Guidelines on Fire Ratings of Archaic Materials and Assemblies - IEBC Chapter Resource A

The **Guideline on Fire Ratings of Archaic Materials and Assemblies** focuses upon the fire-related performance of archaic construction. "**Archaic**" encompasses construction typical of an earlier time, generally prior to 1950. "**Fire-related performance**" includes fire resistance, flame spread, smoke production and degree of combustibility.

10

Harmathy's 10 Rules - See IEBC



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11

Section 104.11 - Alternative Materials, Design and Methods of Construction

104.11 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*.

Alternates are:

- Approved.
- Complies with intent of the code.
- Equivalent to code in:
  - Quality, Strength, Effectiveness, Fire-Resistance, Durability and Safety.

12

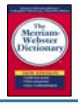
Section 104.11 - Alternative Materials, Design and Methods of Construction

- Dedicated sprinkler for exposed structural column.

13

Chapter 2 - Definitions

- Annular Space
- Building Element
- Combination Fire/Smoke Damper
- Draftstop
- F Rating
- Fire Barrier
- Fire Damper
- Fire Door Assembly
- Fire Partition
- Fire Protection Rating
- Fire Resistance
- Fire-resistance Rating
- Fire-resistant Joint System



14

Chapter 2 - Definitions (continued)

- Fire Separation Distance
- Fire Wall
- Fire Window Assembly
- Fireblocking
- Joint
- Membrane Penetration
- Shaft
- Shaft Enclosure
- Smoke Barrier
- Smoke Compartment
- Through Penetration
- Primary Structural Frame
- Secondary Members

15

Different Types of Fire-Resistance

The provisions of Chapter 7 address four major areas:

1. Structural fire-resistance, regulated primarily by Table 601.

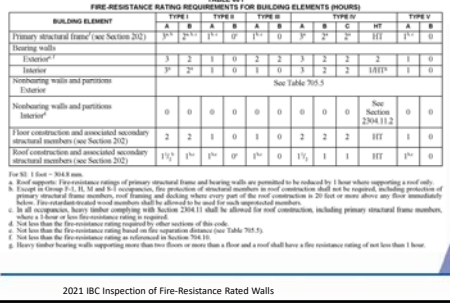


TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[b,h]	2[b,c]	1[b,c]	0[c]	1[b,c]	0	3[c]	2[c]	2[c]	HT	1[b,c]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[c]	2[c]	1	0	1	0	3	2	2	MIT[h]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[g]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[a]	1[a,c]	1[a,c]	0[c]	1[a,c]	0	1½[a]	1	1	HT	1[a,c]	0

For SI: 1 foot = 304.8 mm.
a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.
d. Not less than the fire-resistance rating required by other sections of this code.
e. Not less than the fire-resistance rating based on fire separation distance (see Table 705.5).
f. Not less than the fire-resistance rating as referenced in Section 704.10.
g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

16

Different Types of Fire-Resistance (continued)

The provisions of Chapter 7 address four major areas:

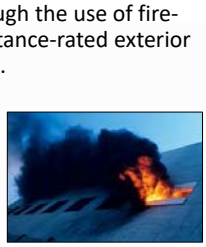
2. Separation of adjacent building spaces through the use of fire-resistance-rated elements, such as fire walls, fire barriers and fire partitions.

3. Separation of adjacent building spaces through the use of smoke-resistant construction, such as smoke barriers and smoke partitions.

17

Different Types of Fire-Resistance (continued)

4. Protection of adjacent buildings from fire spread through the use of fire-resistance-rated exterior walls.



18

Different Types of Fire-Protection

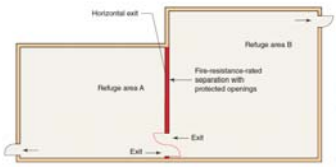
- Penetrations. (Section 714)
- Joint Systems. (Section 715)
- Opening Protectives. (Section 716)
  - Includes doors and windows.
- Ducts and Air Transfer Openings. (Section 717)
  - Dampers.

19

Section 702.1 - Multiple Use Fire Assemblies

Fire assemblies that serve multiple purposes in a building shall comply with all of the requirements that are applicable for each of the individual fire assemblies.

Example: Horizontal exit also serving as a smoke barrier and area of refuge.

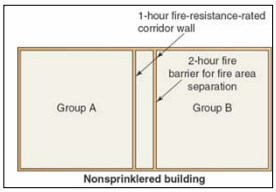


20

Section 702.1 - Multiple Use Fire Assemblies

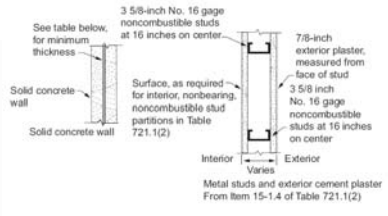
Fire assemblies that serve multiple purposes in a building shall comply with all of the requirements that are applicable for each of the individual fire assemblies.

Example: Rated corridor also serving as a fire area separation. Must meet requirements for both types of separations.



21

Table 721.1(2) - Prescriptive Fire-Resistance



22

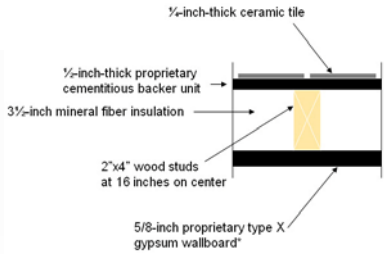
Section 703.2.1.1 – Nonsymmetrical Wall Construction

Interior Walls:

- Nonsymmetrical wall construction to be tested with both faces exposed to the furnace, with the assigned fire-resistance rating based on the shortest duration of the two tests.
  - Where the wall is tested with the least fire-resistant side exposed to the furnace, the wall need not be subjected to tests from the opposite side (if approved by building official).

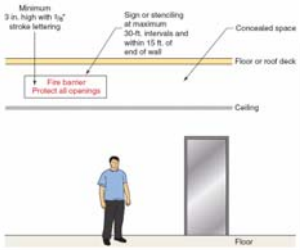
23

Section 703.2.1.1 – Non-Symmetrical Wall Construction



24

Section 703.5 - Marking and Identification



- Signage is only required in accessible concealed spaces.

25

Types of Rated Walls

Types of Rated Walls

There are five types of fire-resistance rated walls:

- Exterior walls. (Section 705)
- Fire walls. (Section 706)
- Fire barriers. (Section 707)
- Fire partitions. (Section 708)
- Smoke barriers. (Section 709)

They each have different purposes and requirements.

27

Section 202 - Definitions

Exterior Wall: A wall, bearing or nonbearing, that is used as an enclosing wall for a building, other than a fire wall, and that has a slope of 60 degrees or greater with the horizontal plane.

28

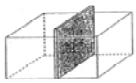
Section 202 - Definitions

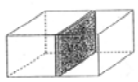
Fire Wall (Area Separation): A fire-resistance-rated wall having protected openings, which restrict the spread of fire and extends continuously from the foundation to or through the roof, with sufficient stability under fire conditions to allow collapse of construction on either side without collapse of the wall.

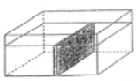
Fire Barrier (Occupancy Separation): A fire-resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained.

Fire Partition (Corridor Wall): A vertical assembly of materials designed to restrict the spread of fire in which openings are protected.

Fire Area (Compartment): The aggregate floor area enclosed and bounded by fire walls, fire barriers, exterior walls or horizontal assemblies of a building. Areas of the building not provided with surrounding walls shall be included in the fire area if such areas are included within the horizontal projection of the roof or floor next above.







29

Purpose of Rated Assemblies

Fire Resistance: That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.

Fire-Resistance Rating: The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.

30

Purpose of Rated Assemblies

Fire Protection Rating: The period of time that an opening protective will maintain the ability to confine a fire as determined by tests prescribed in Section 716. Ratings are stated in hours or minutes.

31

Primary Difference Between Various Walls

- The purpose they serve.
- Continuity/construction requirements.
- Amount and type of opening protection.

32

Section 705: Exterior Walls

33

Section 705 - Exterior Walls

Exterior walls are regulated for fire resistance under these conditions:

- Type of construction requirements (Table 601).
  - For exterior bearing walls.
- Location on lot (Table 705.5).
- Other locations, including:
  - Horizontal continuity of fire walls.
  - Exterior areas for assisted rescue.
  - Egress courts.

34

Table 705.5

TABLE 705.5
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, e, g]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H[d]	OCCUPANCY GROUP F-1, M, S-1[f]	OCCUPANCY GROUP A, B, E, F-2, I, R[c], S-2, U[b]
X < 5[h]	All	3	2	1
5 ≤ X < 10	IA, IVA	3	2	1
	Others	2	1	1
10 ≤ X < 30	IA, IB, IVA, IVB	2	1	1[i]
	IIB, VB	1	0	0
	Others	1	1	1[i]
X ≥ 30	All	0	0	0

For SI: 1 foot = 304.8 mm.
a. Load-bearing exterior walls shall also comply with the fire-resistance rating requirements of Table 601.
b. See Section 706.1.1 for party walls.
c. Open parking garages complying with Section 406 shall not be required to have a fire-resistance rating.
d. The fire-resistance rating of an exterior wall is determined based upon the fire separation distance of the exterior wall and the story in which the wall is located.
e. For special requirements for Group H occupancies, see Section 415.6.
f. For special requirements for Group S aircraft hangars, see Section 412.3.1.
g. Where Table 705.8 permits nonbearing exterior walls with unlimited area of unprotected openings, the required fire-resistance rating for the exterior walls is 0 hours.
h. For a building containing only a Group U occupancy private garage or carport, the exterior wall shall not be required to have a fire-resistance rating where the fire separation distance is 5 feet (1523 mm) or greater.
i. For a Group R-3 building of Type II-B or Type V-B construction, the exterior wall shall not be required to have a fire-resistance rating where the fire separation distance is 5 feet (1523 mm) or greater.

35

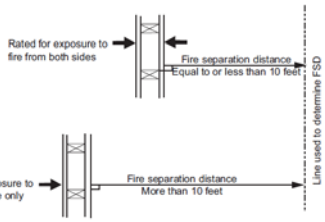
Section 705.5 - Exterior Wall – Fire-Resistance Ratings

Exterior walls shall be rated for exposure to fire from:

- Both sides where the separation distance is **10'** or less.
- The inside where the fire separation distance exceeds **10'**.

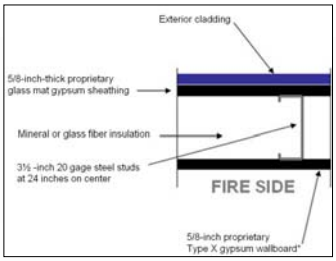
36

Section 705.5 - Exterior Wall - Fire-Resistance Ratings



37

Section 705.5 - Exterior Wall - Fire-Resistance Ratings



38

Section 705.8 – Openings

Maximum area of unprotected or protected openings located in an exterior wall is limited by Table 705.8.

- Values are the percentage of area of the exterior wall per story.
- Unlimited unprotected openings are permitted where an exterior wall does not require a fire-resistance rating in accordance with Table 705.5.

39

Table 705.8

TABLE 705.8
MAXIMUM AREA OF EXTERIOR WALL OPENINGS BASED ON FIRE SEPARATION DISTANCE AND DEGREE OF OPENING PROTECTION

FIRE SEPARATION DISTANCE (feet)	DEGREE OF OPENING PROTECTION	ALLOWABLE AREA*
0 to less than 3[b,c,h]	Unprotected, Nonsprinklered (UP, NS)	Not Permitted[f]
	Unprotected, Sprinklered (UP, S)[i]	Not Permitted[f]
	Protected (P)	Not Permitted[f]
3 to less than 5[c,e]	Unprotected, Nonsprinklered (UP, NS)	Not Permitted
	Unprotected, Sprinklered (UP, S)[i]	15%
	Protected (P)	15%
5 to less than 10[c,g,i]	Unprotected, Nonsprinklered (UP, NS)	10%[j]
	Unprotected, Sprinklered (UP, S)[i]	25%
	Protected (P)	25%
10 to less than 15[c,f,g,i]	Unprotected, Nonsprinklered (UP, NS)	15%[j]
	Unprotected, Sprinklered (UP, S)[i]	45%
	Protected (P)	45%
15 to less than 20[d,g,i]	Unprotected, Nonsprinklered (UP, NS)	25%
	Unprotected, Sprinklered (UP, S)[i]	75%
	Protected (P)	75%
20 to less than 25[d,g,i]	Unprotected, Nonsprinklered (UP, NS)	45%
	Unprotected, Sprinklered (UP, S)[i]	No Limit
	Protected (P)	No Limit

(Partial Table)

40

Section 705.8.4 – Mixed Openings

Where both protected and unprotected openings are located in an exterior wall of any story, the total area of openings are to comply with following formula:

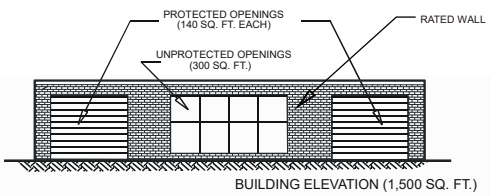
$$(A_p/a_p) + (A_u/a_u) \leq 1 \qquad \textbf{Equation 7-2}$$

Where:

A_p = Actual area of protected openings, or the equivalent area of protected openings, A_e.
a_p = Allowable area of protected openings.
A_u = Actual area of unprotected openings.
a_u = Allowable area of unprotected openings.

41

$$\frac{\text{Actual protected}}{\text{allowable protected}} + \frac{\text{Actual unprotected}}{\text{allowable unprotected}} \leq 1$$



$$\frac{300 \text{ ft.}^2}{375} + \frac{280 \text{ ft.}^2}{1125}$$

.80 + .25 = 1.05

Total exceeds value of 1 and must be revised.

See Table 705.8

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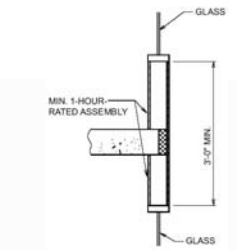
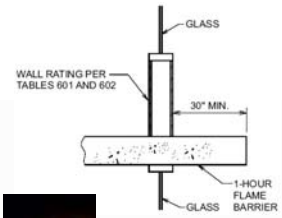
Section 705.8.5 - Vertical Separation of Openings

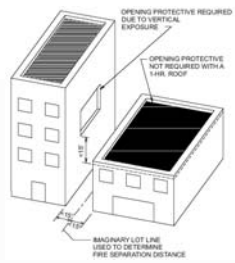




Leap-frogging

43

Section 705.8.6 - Vertical Exposure



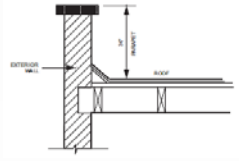
- Applicable to buildings on the same lot. (Not at lot lines).
- See exceptions:
  - One-hour roof on lower building.
  - Buildings considered as one building.

44

Sections 705.11 & 705.11.1 - Parapets; Parapet Construction

Parapets shall be provided on exterior walls of buildings:

- Same fire-resistance rating as the supporting wall.
- Side adjacent to roof surface to have noncombustible facing for uppermost **18”**.
- Height above the roof surface to be at least **30”.**



45

Section 705.11 - Exceptions 1-3

Parapets need not be provided on exterior walls of buildings where any of the following conditions exist:

1. The wall is not required to be fire-resistance rated in accordance with Table 602 because of fire separation distance.
2. The building has an area of not more than **1,000 sq.ft.** on any floor.
3. Walls that terminate at roofs of not less than **2-hr.** fire-resistance-rated construction or where the roof, including the deck and supporting construction, is constructed entirely of noncombustible materials.

46

Section 705.11 - Exception 6

Where the wall is permitted to have at least 25% unprotected openings based on fire separation distance in accordance with Table 705.8:

- For fully sprinklered buildings, this distance would be greater than **5’** or greater.
- For non-sprinklered buildings, this distance would be greater than **15’** or greater.

47

Section 706: Fire Walls

48

202 Fire Walls

- Fire walls are fire-resistance-rated walls having protected openings, which restricts the spread of fire and extends continuously from the foundation to or through the roof.

49

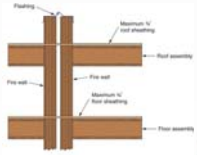
503.1 Fire Walls

- Fire walls are typically used to create separate buildings for the purposes of determining:
  - Area limitations
  - Height limitations
  - Type of construction
  - Allowable number of control areas

50

706.2 Structural Stability

- Fire walls to be designed and constructed to allow collapse of the structure on either side without collapse of the wall under fire conditions.
  - Fire walls designed and constructed per NFPA 221 are deemed to comply.
    - Exception for SDCs D through F:



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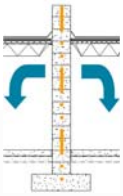
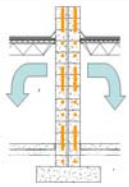
Section 706.2 - Structural Stability





Fire-Resistance Ratings for Double Wall Assemblies	
Fire-Resistance Rating of Each Wall (Hour)	Equivalent to Single Wall (Hour)
3	4
2	3
1	2

52

Table 706.4

TABLE 706.4
FIRE WALL FIRE-RESISTANCE RATINGS

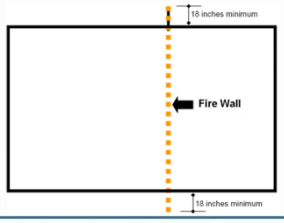
GROUP	FIRE-RESISTANCE RATING (hours)
A, B, E, H-4, I, R-1, R-2, U	3[a]
F-1, H-3b, H-5, M, S-1	3
H-1, H-2	4[b]
F-2, S-2, R-3, R-4	2

a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.
b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.7 and 415.8.

53

Section 706.5 - Horizontal Continuity

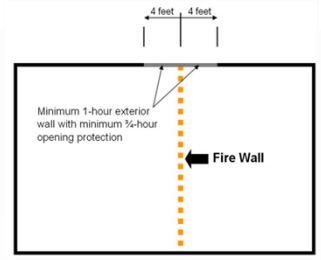
- Fire walls shall extend a minimum of **18'** beyond the exterior surface of exterior walls.
- Several exceptions allow for an alternative means of protection.



54

Section 706.5 - Exception 1

- Terminate at the interior surface of combustible exterior sheathing or siding.

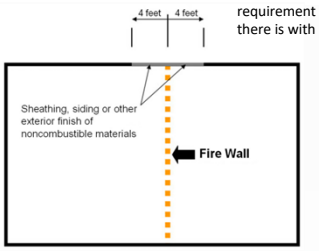


2021 IBC Inspection of Fire-Resistance Rated Walls 55

55

Section 706.5 - Exception 2

- Terminate at the interior surface of non-combustible exterior sheathing, siding or finish.
- No opening protection requirement in this 4' area as there is with Exception 1.



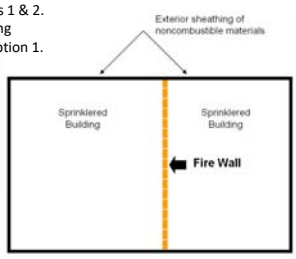
2021 IBC Inspection of Fire-Resistance Rated Walls 56

56

Section 706.5 - Exception 3

- Terminate at the interior surface of noncombustible exterior sheathing in sprinklered building.

- No specific distance established for the sheathing as with Exceptions 1 & 2.
- Nothing stated about opening protection as stated in Exception 1.

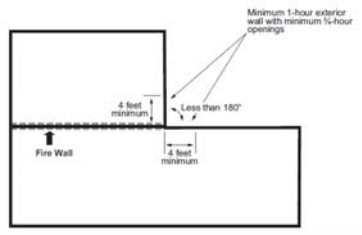


2021 IBC Inspection of Fire-Resistance Rated Walls 57

57

Section 706.5.1, #1 - Exterior Walls

- Protect wall for 4' and protect any openings in that area.

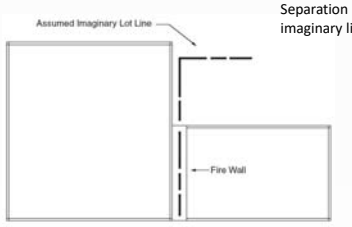


2021 IBC Inspection of Fire-Resistance Rated Walls 58

58

Section 706.5.1, #2 - Exterior Walls

- Establish an imaginary property line and deal with the adjacent exterior walls accordingly.
- Base the adjacent wall and opening protection on the Fire Separation Distance from that imaginary line.

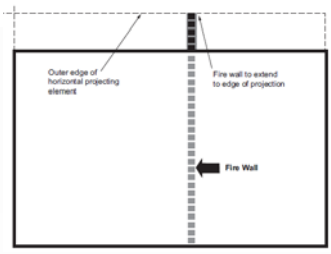


2021 IBC Inspection of Fire-Resistance Rated Walls 59

59

Section 706.5.2 - Horizontal Projecting Elements

- Fire walls shall extend to the outer edge of horizontal projecting elements that are within 4' of the fire wall.

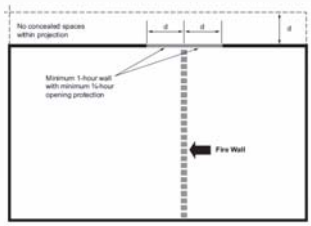


2021 IBC Inspection of Fire-Resistance Rated Walls 60

60

Section 706.5.2 - Exception 1

- Fire walls need not extend to outer edge of projection where the:
  - Projection contains no concealed space; and
  - Exterior walls behind and below projection for depth of the projecting element **'d'** are a minimum of 1 hour with ¾-hour opening protection.



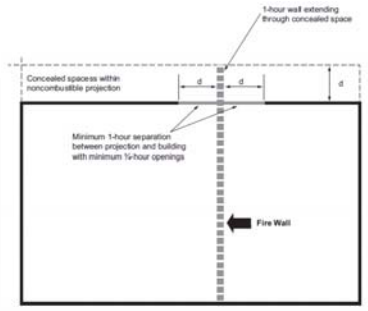
61

Section 706.5.2 - Exception 2

- Fire walls need not extend to outer edge of a noncombustible projection that contains concealed space, if:
  - A 1-hour wall extends through a concealed space; and
  - Exterior walls both within and below the projection for the depth of the projecting element 'd" are a minimum of 1 hour with ¾-hour opening protection.
  - Wall that extends through projection is not required to extend below the projection (just through the projection). This requirement is not applicable to the "exterior" wall that is to each side of the fire wall, just to the wall that extends out through the projection

62

Section 706.5.2 - Exception 2



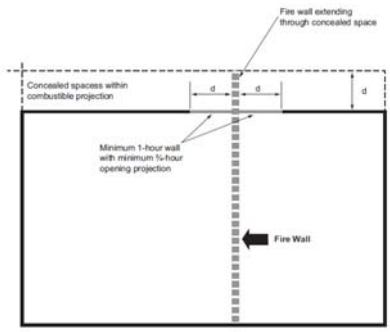
63

Section 706.5.2 - Exception 3

- Fire walls need not extend to outer edge of noncombustible projection that contains concealed space if the:
  - Fire wall extends through the concealing space; and
  - Exterior wall behind and below the projection for the depth of the projecting element, 'd', are a minimum of 1 hour with ¾-hour opening protection.
  - Fire wall extends through concealed projection – not beneath it.

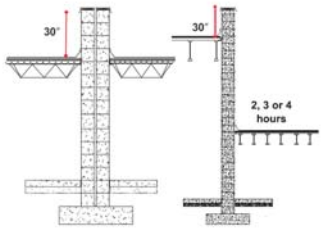
64

Section 706.5.2 - Exception 3



65

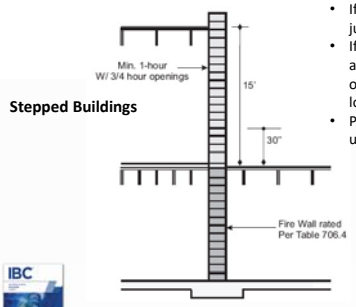
Section 706.6 - Vertical Continuity



- Fire walls shall extend from the foundation to a termination point at least 30" above **both** adjacent roofs.

66

Section 706.6 - Exception 1
Section 706.6.1 – Stepped Buildings

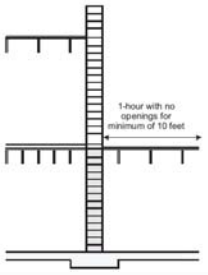


Stepped Buildings

- If higher building is not 15' higher, then just protect for full height.
- If higher building is more than 15' above lower roof, then only the portion of the exterior wall that is within 15' of lower roof is protected.
- Portions above that height are unprotected.

67

Section 706.6 - Exception 1
Section 706.6.1, Exception



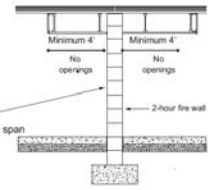
Roof Protection for Stepped Building

- As an alternative, the fire wall may terminate at the underside of the roof sheathing, deck or slab of the lower roof, provided:
1. The lower roof assembly within 10' of the wall has not less than a 1-hour fire-resistance rating, and the entire length and span of supporting elements for the rated roof assembly has a fire-resistance rating of not less than 1 hour.
2. Openings in the lower roof shall not be located within 10' of the fire wall.

68

Section 706.6 - Exception 2

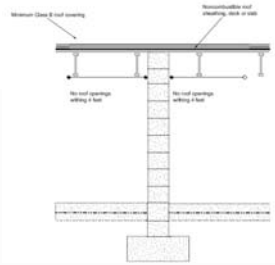
2. Two-hour fire-resistance-rated walls shall be permitted to terminate at the underside of the roof sheathing, deck or slab provided:
   - The roof assembly is protected for 1 hour and is within 4' of wall; the entire length and span of supporting elements are also protected for 1 hour.
   - No openings within 4'.
   - Minimum Class B roof covering.



- Roof of same height
- Two-hour FW
- One-hour, 4 foot entire span span and supporting elements
- No roof openings within 4 ft of FW

69

Section 706.6 - Exception 3

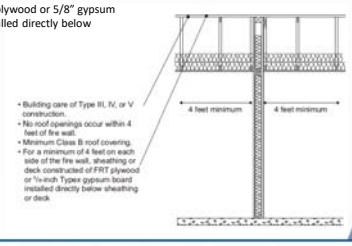


3. Walls are permitted to terminate at the underside of noncombustible roof sheathing, deck or slab where:
   - Both buildings are provided with minimum Class B roof coverings.
   - No roof openings are located within 4' of the fire wall.

70

Section 706.6 - Exception 4

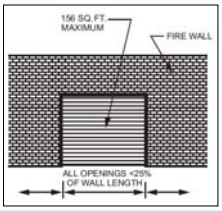
4. Fire walls may terminate at the underside of noncombustible roof sheathing, deck or slab where:
   - Buildings are of Type III, IV or V construction.
   - No roof openings occur within 4' of the fire wall.
   - Minimum Class B roof covering.
   - For a minimum of 4' on each side of the fire wall, sheathing or deck constructed of fire-retardant-treated plywood or 5/8" gypsum board shall be installed directly below sheathing or deck.



71

Section 706.8 - Openings

- Each opening through a fire wall shall be protected in accordance with Section 716.5 and shall not exceed **156 sq.ft.**
- The aggregate width of openings at any floor level shall not exceed **25%** of the length of the wall.



72

Section 706.8 - Openings

- Exceptions:
  1. Openings are not permitted in party walls.
  2. Openings are not limited to **156 sq.ft**. where both buildings are equipped throughout with an NFPA 13 automatic sprinkler system.
- Ducts and air openings may penetrate a fire wall (other than a party wall) provided they are protected in accordance with Sections 717.

73

Section 707: Fire Barriers

74

Section 707 - Fire Barriers

A fire-resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained.

Used for:

- Shaft enclosures
- Stairway and ramp enclosures
- Exit passageways
- Horizontal exits
- Atrium enclosures
- Incidental uses
- Control areas
- Separated occupancies
- Fire areas

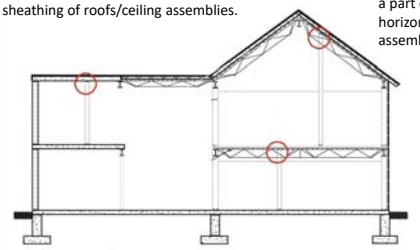
75

Section 707.5 - Continuity

Fire barriers are to extend from the top of the floor/ceiling assembly below to the underneath side of:

- Floor slabs.
- Roof slabs.
- Floor sheathing of floors/ceiling assemblies.
- Roof sheathing of roofs/ceiling assemblies.

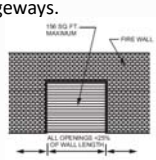
- Cannot stop at the ceiling, even if it is a part of a rated horizontal assembly.



76

Section 707.6 - Openings

- Openings in a fire barrier to be protected in accordance with Section 716.
- Openings shall be limited to:
  - Maximum aggregate width of **25%** of wall length. (See exceptions)
  - **156 sq.ft.** per single opening. (See exceptions)
  - Additional limitations for exit or exit access stairway and ramp enclosures and exit passageways.



77

Section 708: Fire Partitions

78

Section 708 - Fire Partitions

A vertical assembly of materials designed to restrict the spread of fire in which openings are protected.

Selectively used for:

- Walls separating dwelling/sleeping units.
- Walls separating tenant spaces in mall buildings.
- Corridor walls.
- Elevator lobbies.
- Egress balconies.
- Walls separating ambulatory care facilities.
- Vestibules.

79

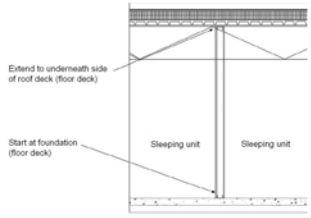
Section 708.4 Continuity

- Fire partition provisions address three distinct areas:
  - Continuity in regard to enclosure limits.
  - Supporting construction components.
  - Fireblocking and draftstopping.

80

Section 708.4, #1 Continuity

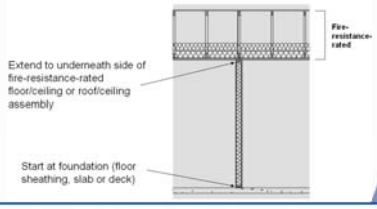
- Option 1: Fire partitions to extend from top of foundation or floor/ceiling assembly below to underside of:
  - Floor or roof sheathing, deck or slab above



81

Section 708.4 Continuity

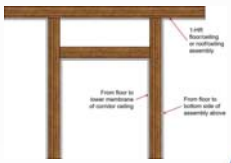
- Option 2: Fire partitions to extend from top of foundation or floor/ceiling assembly below to underside of:
  - Floor/ceiling or roof/ceiling assembly rated not less than the fire partition.



82

Section 708.4 Continuity, Exception 2.1

- Fire partitions not required to extend above lower membrane of corridor ceiling, if:
  - Room-side membrane of corridor wall extends to underside of floor or roof sheathing, deck or slab of FRR floor or roof above.



83

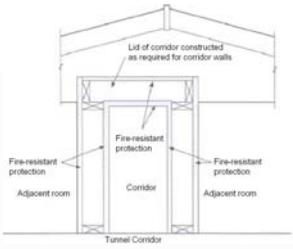
Section 708.4 Continuity, Exception 2.2

- Optional enclosure continuity method for corridor walls that do not extend above lower membrane of corridor ceiling:
  - Applicable to sprinklered buildings where sprinklers installed in concealed space.

84

Section 708.4 – Exception 3 Tunnel Corridor

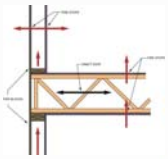
- Allows corridor ceiling to be constructed as required for wall.
- Requires "corridor damper" if duct penetrates this horizontal assembly.



85

708.4.2 Fireblocking and Draftstopping at Fire Partitions

- In combustible construction where fire partitions do not extend to the underside of the floor or roof deck above, the space above and along line of fire partition to be fireblocked and draftstopped per Section 718.
  - Five exceptions reduce or eliminate fireblocking and draftstopping requirements.



86

Section 709: Smoke Barriers

87

Section 709 - Smoke Barriers

A continuous membrane, either vertical or horizontal, such as a wall, floor or ceiling assembly, that is designed and constructed to restrict the movement of smoke.

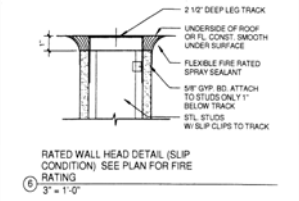
Selectively required in:

- Underground buildings.
- Group I-2 and I-3.
- Ambulatory care facilities.
- Areas of refuge.
- Smoke control systems.

88

Section 709.3 - Fire-Resistance Rating

- **Fire-resistance rating.** A minimum **1-hr.** fire-resistance rating is required for smoke barriers.
  - Exception: Smoke barriers constructed of minimum 0.10-inch-thick steel in Group I-3 buildings.



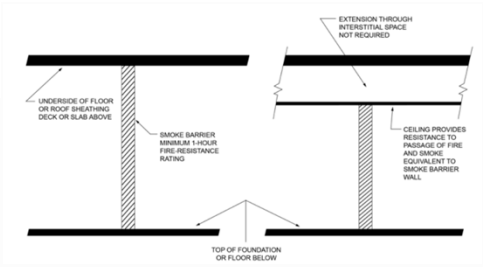
89

Section 709.4 - Continuity

- Smoke barriers shall form an effective membrane continuous from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, deck or slab above, including continuity through concealed spaces, such as those found above suspended ceilings, and interstitial structural and mechanical spaces.
  - Smoke barriers not required in interstitial spaces where such spaces designed with ceilings or exterior walls that provide resistance to passage of fire and smoke in a manner equivalent to smoke barrier walls.

90

Section 709.4 - Continuity



Smoke Barrier Continuity Requirements

91

Section 709.4.1 & 709.4.2 - Continuity

- Walls creating smoke compartments must extend from outside wall to outside wall.
- Walls creating areas of refuge or elevator lobbies shall terminate at a fire barrier, another smoke barrier or an outside wall.

92

Section 709.5 - Openings

- Openings in smoke barriers to comply with Section 716:
  - Minimum **20-minute** fire-protection rating.
  - Meet requirements for a smoke and draft control door assembly tested in accordance with UL 1784.

93

Section 714: Penetrations

94

You Have Got To Fix The Holes!

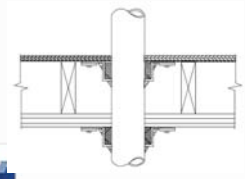
In order for the fire-resistance to be effective (and really work) you need to protect any openings into or through it.

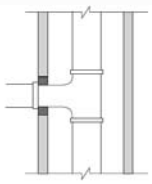
- Penetrations. (Section 714)
- Joints and voids. (Section 715)
- Opening protectives (doors and windows). (Section 716)
- Ducts and air transfer openings (dampers). (Section 717)

95

Section 202 - Definitions - Types of Penetrations

- **Through Penetration:** Breach in both sides of an assembly to accommodate an item passing through breaches.
- **Membrane Penetration:** Breach in one side of an assembly to accommodate an item passing through breaches.





96

Section 714 - Penetrations

Penetrations of fire walls, fire barriers, smoke barrier walls and fire partitions to be protected by one of three basic methods:

- Tested as a part of the original fire-resistive assembly test.
- Tested as a Penetration Firestop System – complying with ASTM E814 or UL 1479.
- Comply with one of the exceptions listed in Sections 714.4.1 or 714.4.2 (Through or Membrane penetration provisions).

97

Penetration Firestop Systems

- Review and understand definitions!
- Tested and listed as a system. Must be installed and used for walls and penetrants as tested.
- Required to have an "F" rating of not less than the fire-resistance rating of the wall. (Section 714.4.1.2)
- Required to have an "L" rating for penetrations in smoke barriers. (Sections, 714.4, 714.5.4)

98

Penetration Firestop Systems

- **"F" rating:** Time period that limits spread of fire through penetration firestop system**.**
- **"T" rating:** Time period that limits maximum 325F temperature rise through penetration firestop system**.**
- **"S" rating:** Time period that resists passage of smoke through penetration firestop system**.**
- **"L" rating:** Air leakage rate through penetration firestop system**.**

99

Special Inspection – Section 1705.18 – Fire-Resistant Penetrations & Joints

Special inspection of penetration firestops, joint systems and perimeter fire containment systems is required in:

- High-rise buildings.
- Buildings in Risk Category III or IV in accordance with Section 1604.5.
- Fire areas containing Group R occupancies with an occupant load exceeding 250

100

Risk Category III – Table 1604.5

Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to:

- Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300.
- Buildings and other structures containing one or more public assembly spaces, each having an occupant load greater than 300 and a cumulative occupant load of the public assembly spaces of greater than 2,500.
- Buildings and other structures containing Group E or Group I-4 occupancies or combination therof, with an occupant load greater than 250.
- Buildings and other structures containing educational occupancies for students above the 12th grade with an occupant load greater than 500.
- Group I-2, Condition 1 occupancies with 50 or more care recipients.
- Group I-2, Condition 2 occupancies not having emergency surgery or emergency treatment facilities.
- Group I-3 occupancies.
- Any other occupancy with an occupant load greater than 5,000.
- Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV.
- Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that:
  - Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the International Fire Code; and
  - Are sufficient to pose a threat to the public if released.

101

Risk Category IV – Table 1604.5

Buildings and other structures designated as essential facilities, including but not limited to:

- Group I-2, Condition 2 occupancies having emergency surgery or emergency treatment facilities.
- Ambulatory care facilities having emergency surgery or emergency treatment facilities.
- Fire, rescue, ambulance and police stations and emergency vehicle garages
- Designated earthquake, hurricane or other emergency shelters.
- Designated emergency preparedness, communications and operations centers and other facilities required for emergency response.
- Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures.
- Buildings and other structures containing quantities of highly toxic materials that:
- Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the International Fire Code; and
- Are sufficient to pose a threat to the public if released.
- Aviation control towers, air traffic control centers and emergency aircraft hangars.
- Buildings and other structures having critical national defense functions.
- Water storage facilities and pump structures required to maintain water pressure for fire suppression

102

Special Inspection – Section 1705.19 – Testing for Smoke Control

Special inspection of smoke control systems is required:

- During erection of ductwork.
- Prior to concealing for leakage testing.
- Prior to occupancy.

103

Section 714.4.1 - Exception 1

Where penetrating items are **steel, ferrous or copper pipes, tubes or conduit**, annular space protection using concrete, grout or mortar is permitted in lieu of a listed firestop system where:

- Penetrating items are steel, ferrous or copper pipes, tubes or conduits.
- Walls are of concrete or masonry.
- Penetrating item a maximum of **6"** in diameter.
- Area of wall opening limited to **144 sq.in (@13.5" dia)**.
- Annular space protection is installed to full thickness of the wall or thickness required to maintain fire-resistance rating.

104

Section 714.4.1 – Exception 2

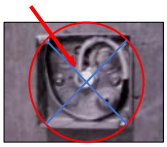
- Where penetrating items are **steel, ferrous or copper pipes, tubes or conduit**, annular space protection is permitted in lieu of a listed firestop system where material used to fill the annular space is shown to prevent the passage of flame and hot gases in accordance with ASTM E119 or UL 263.

105

Section 714.4.2 - Exception 1

Membrane penetrations of steel electrical boxes may be made subject to the following conditions:

- Walls to be maximum **2 hrs**.
- Boxes to be a maximum of **16 sq.in.**
- Aggregate area of boxes not to exceed **100 sq.in. per 100 sq.ft. of wall area**.
- Annular space between the box and wall membrane is not to exceed **1/8"**.
- Boxes on the opposite sides of a wall or partition to be adequately separated or protected (five methods available).



Boxes are back-back. No separation.

106

Section 714.4.2 - Exception 2

Membrane penetrations of listed electrical boxes of any material may be made subject to the following conditions:

- Boxes have been tested for use in a fire-resistance-rated assembly.
- Boxes are installed in accordance with their listing.
- Annular space between the box and wall membrane is not to exceed **1/8"**.
- Boxes on the opposite sides of a wall or partition to be adequately separated or protected (four methods available).

107

Section 714.4.2 - Exceptions 3 & 4

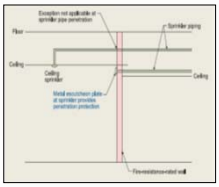
Electrical boxes of any size or type are permitted as complying membrane penetrations provided they have been listed as part of a wall opening protective material system.

108

Section 714.4.2 - Exception 5

Membrane penetrations created by the penetration of an automatic sprinkler need not be protected by an approved firestop system provided the annular space is covered by a metal escutcheon plate.

- Exception is for a sprinkler, not for a line of sprinkler piping.



109

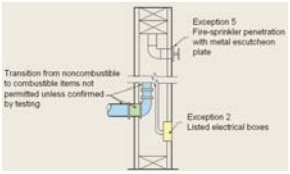
Section 714.4.2 - Exception 6

- Similar in many ways to **Exception 1** but accepts boxes that exceed **16 sq.in.** size
- Relies on "protected by listed putty pads or other listed material"
- Must be installed in accordance with the listing
- Listing would address issues of back-to-back penetrations

110

Section 714.4.3 - Dissimilar Materials

- Noncombustible penetrating items shall not connect to combustible items beyond the point of firestopping.



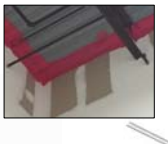
111

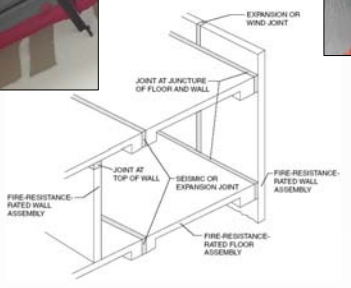
Section 715 – Joints and Voids

- This section regulates joints or linear openings created between building assemblies, which are sometimes referred to as head-of-wall, expansion or seismic joints.
- These joints are most often created where the structural design of a building necessitates a separation between building components in order to accommodate anticipated structural displacements caused by thermal expansion and contraction, seismic activity, wind or other loads.
- It also addresses voids at the intersection of floors and exterior curtain walls.

112

Section 715.1 - Examples of Locations

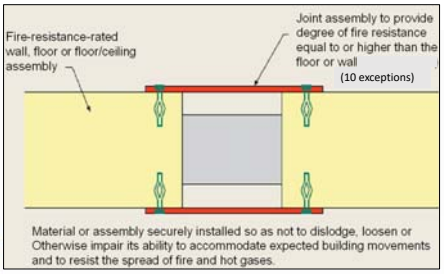




113

Section 715.1 - General

- Joints to be protected with approved fire-resistant joint systems.



114

Section 715.1 - Exceptions

Fire-resistant joint systems are not required in the following locations:

Locations:

- Within a single dwelling unit.
- Where the joint is protected by a shaft enclosure.
- Within atriums.
- Within malls.
- Within open parking garages.
- Mezzanines.
- Walls permitted to have unprotected openings.
- Roofs where openings are permitted.
- Maximum **5/8"** wide control joints (tested in accordance with ASTM E119 or UL 263).
- Intersection of exterior curtain wall and floor

115

Section 715.4 – Exterior Curtain Wall/Rated Floor Intersections

- Voids created at intersection of exterior curtain wall assemblies and **fire-resistance-rated** floor or floor/ceiling assemblies to be protected with an approved **perimeter fire containment system**.
- Such systems to have an F rating no less than that required for the floor or floor/ceiling assembly.

116

Section 715.5 – Exterior Curtain Wall/Nonrated Floor Intersections

- Voids created at intersection of exterior curtain wall assemblies and **nonfire-resistance-rated** floor or floor/ceiling assemblies to be filled with an approved material or system to retard the interior spread of fire and hot gases between stories.

117

Section 715.6 – Exterior Curtain Wall/Nonrated Floor Intersections

- Voids created at intersection of **nonfire-resistance-rated** exterior curtain wall assemblies and **fire barriers** to be filled with an approved material or system to retard the interior spread of fire and hot gases between stories.

118

Section 716 - Opening Protectives

This section regulates two types of opening protectives:

- Fire door and shutter assemblies (716.2).
- Fire window assemblies (716.3).

119

Section 716 – Opening Protectives - "Approved" Hold-Open Device

120

Section 716 – Opening Protectives - "Un-Approved" Hold-Open Devices

2021 IBC Inspection of Fire-Resistance Rated Walls 121

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Section 716.1 - General

Fire door and fire shutter assemblies shall be:

- Side hinged or pivoted.
- "Other doors" (fire shutters or swinging elevator doors, chute intake and discharge doors, etc.).
- Corridor and smoke barrier doors.
- Tin clad doors.
- Floor fire doors.

Fire-protection-rated glazing permitted in:

- "Fire windows."
- Vision panels in door assemblies

2021 IBC Inspection of Fire-Resistance Rated Walls 122

122

Section 716.1.1 – Alternative Methods for Determining Fire Protection Rating

Required fire resistance of opening protective:

- Designs documented in approved sources.
- Calculations performed in approved manner.
- Engineering analysis based on NFPA or UL.
- Alternative protection methods allowed by Section 104.11.

2021 IBC Inspection of Fire-Resistance Rated Walls 123

123

Section 716.1.2.2.1 - Fire-Resistance-Rated Glazing

- Labeled fire-resistance-rated glazing tested as part of a fire-resistance-rated wall or floor/ceiling assembly, in accordance with ASTM E119 or UL 263, is not required to comply with Section 716.
- Fire-resistance-rated glazing is permitted in fire doors and fire windows when installed in accordance with listing and requirements of Section 716.

2021 IBC Inspection of Fire-Resistance Rated Walls 124

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Sections 716.1.2.2.1 - Fire-Rating Glazing Identification

Glazing to be labeled with 4-part identifier:

- "D": applicable for fire-door assemblies and meets applicable fire-resistance requirements
- "H": meets hose stream requirements
- "T": meets temperature requirements
- "XXX": fire-protection rating in minutes

Fire Door Glazing Identification Requirements

2021 IBC Inspection of Fire-Resistance Rated Walls 125

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Table 716.1(1) - Marking Fire-Rated Glazing Assemblies

TABLE 716.1(1)
MARKING FIRE-RATED GLAZING ASSEMBLIES

FIRE TEST STANDARD	MARKING	DEFINITION OF MARKING
ASTM E119 or UL 263	W	Meets wall assembly criteria.
ASTM E119 or UL 263	FC	Meets floor/ceiling criteria[a]
NFPA 257 or UL 9	OH	Meets fire window assembly criteria including the hose stream test.
NFPA 252 or UL 10B or UL 10C	D H T	Meets fire door assembly criteria. Meets fire door assembly hose stream test. Meets 450°F temperature rise criteria for 30 minutes
—	XXX	The time in minutes of the fire resistance or fire protection rating of the glazing assembly.

a. See Section 2409.1

2021 IBC Inspection of Fire-Resistance Rated Walls 126

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Table 716.1(2) - Opening Fire Protection

TABLE 716.1(2)
OPENING FIRE PROTECTION ASSEMBLIES, RATINGS AND MARKINGS

TYPE OF ASSEMBLY	REQUIRED WALL ASSEMBLY RATING (hours)	MINIMUM FIRE DOOR AND FIRE SHUTTER ASSEMBLY RATING (hours)	DOOR VISION PANEL SIZE[a]	FIRE-RATED GLAZING MARKING DOOR VISION PANEL[b,c]	MINIMUM SIDELIGHT/ TRANSOM ASSEMBLY RATING (hours)		FIRE-RATED GLAZING MARKING SIDELIGHT/TRANSOM PANEL	
					Fire protection	Fire resistance	Fire protection	Fire resistance
Fire walls and fire barriers having a required fire-resistance rating greater than 1 hour	4	3	See Note a	D-H-W-240	Not Permitted	4	Not Permitted	W-240
	3	3[d]	See Note a	D-H-W-180	Not Permitted	3	Not Permitted	W-180
	2	1½	100 sq. in.	≤100 sq. in. = D-H-90 >100 sq. in.=D-H-W-90	Not Permitted	2	Not Permitted	W-120
	1½	1½	100 sq. in.	≤100 sq. in. = D-H-90 >100 sq. in.= D-H-W-90	Not Permitted	1½	Not Permitted	W-90

(partial Table)

- This table lists the minimum fire protection ratings for fire doors relative to the nature and fire-resistance rating of the wall.

127

Section 716.2.5 - Glazing Material in Fire Door Assemblies

Review Table 716.5 and Section 716.2.5 for limitations on glazing in fire doors.

Provisions vary depending on:

- Fire-protection rated glazing or fire-resistance-rated glazing.
- Type and location of wall assembly.

- Verify glazing is properly labeled. (716.2.9.5 & 716.3)
- Comply with safety glazing provisions. (716.1.2.1)

128

Section 716.2.6.1 - Door Closing

- Fire doors shall be self-closing or automatic closing and shall latch to secure the door.
- Automatic-closing devices are required for certain locations. Example is cross-corridor doors installed in a:
  - Smoke-barrier wall in a Group I-2 occupancy.
  - Horizontal exit wall.

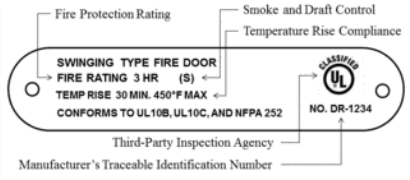
129

Section 716.2.6.6 - Smoke-Activated Doors

Where automatic-closing doors are installed, activation by smoke detectors are required at 8 specific locations.

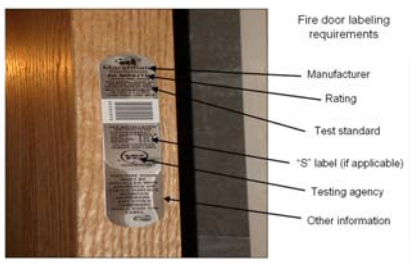
130

Section 716.2.9.1 - Fire Door Labeling Requirements



131

Section 716.2.9.1 - Fire Door Labeling Requirements



132

Section 716.3.4 - Fire-Protection-Rated Glazing

- Glazing in fire window assemblies shall comply with Table 716.1(3).
- Remember fire-resistance-rated glazing is permitted in fire doors and fire window assemblies where tested and installed in accordance with the listing and must comply with Section 716 when used in these locations.

133

Table 716.1(3)

TABLE 716.1(3)
FIRE WINDOW ASSEMBLY FIRE PROTECTION RATINGS

TYPE OF WALL ASSEMBLY	REQUIRED WALL ASSEMBLY RATING (hours)	MINIMUM FIRE WINDOW ASSEMBLY RATING (hours)	FIRE-RATED GLAZING MARKING
Interior walls			
Fire walls	All	NP[a]	W-XXX[b]
Fire barriers	>1	NP[a]	W-XXX[b]
	1	NP[a]	W-XXX[b]
Atrium separations (Section 707.3.6), Incidental use areas (Section 707.3.7),[c] Mixed occupancy separations (Section 707.3.9)	1	3/4	OH-45 or W-60
Fire partitions	1	3/4	OH-45 or W-60
	0.5	1/3	OH-20 or W-30
Smoke barriers	1	3/4	OH-45 or W-60
	>1	1 1/2	OH-90 or W-XXX[b]
Exterior walls	1	3/4	OH-45 or W-60
	0.5	1/3	OH-20 or W-30
Party wall	All	NP	Not Applicable

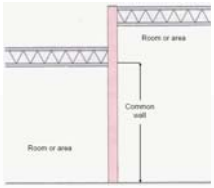
NP = Not Permitted.

(exceptions not shown)

134

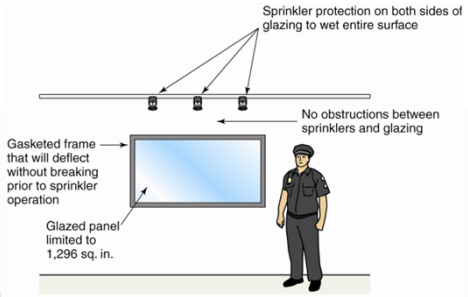
Section 716.3.2.1 - Interior Fire Window Assemblies

- **3/4 hr.** fire-protection-rated glazing used in fire window assemblies shall be limited to use in fire partitions and fire barriers where the fire-resistance rating of the wall assembly does not exceed **1 hr**.
- **20 minute** rating allowed in smoke barriers and fire partitions requiring **20 minute** opening protection.
- The total aggregate window area shall not exceed **25%** of the area of the **common wall** between any rooms.



135

Section 408.7 - Security Glazing



Security glazing in Group I-3 occupancies

136

Section 717: Ducts and Air Transfer Openings

137

Section 717 - Ducts & Air Transfer Openings

- Fire dampers, smoke dampers and combination fire/smoke dampers protect openings created by duct penetrations and air transfer openings in those fire-resistance-rated assemblies required to be protected.
- Ducts that penetrate fire-resistance-rated wall assemblies and are not required to have dampers shall comply with the provisions of Section 714.3 through 714.4.3 and are regulated as penetrations.

138

Section 717.3 - Damper Testing, Ratings and Actuation

Dampers shall be listed, labeled and in compliance with the following standards:

- Fire dampers: UL 555.
- Smoke dampers: UL 555S.
- Combination fire/smoke dampers to comply with both UL 555 and 555S.
  - A "corridor damper" is a specific type of combination damper used in the ceiling of a tunnel type corridor.

139

Section 717.3.2 - Damper Ratings

TABLE 717.3.2.1
FIRE DAMPER RATING

TYPE OF PENETRATION	MINIMUM DAMPER RATING (hours)
Less than 3-hour fire-resistance-rated assemblies	1.5
3-hour or greater fire-resistance-rated assemblies	3

Smoke dampers shall be rated as follows:

- Leakage ratings shall be Class I or Class II.
- Elevated temperature ratings shall not be less than 250° F.

140

717.4 Access and Identification

- Dampers equipped with fusible links and/or internal operators to be provided with a:
  - Minimum 12 inch by 12 inch access door, or
  - Removable duct section.
- Where space constraints or physical barriers restrict damper access for periodic inspection and testing, the damper to be a single- or multi-blade type and comply with remote inspection requirements of NFPA 80 or NFPA 105.
  - Requirements for maintenance and periodic inspection found in IFC Section 706.1
- Access points to be identified by minimum ½"-high letters reading "FIRE /SMOKE DAMPER," SMOKE DAMPER" or "FIRE DAMPER."

141

Section 717.5 - Where Required

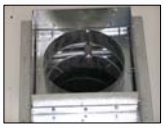
The type and location of dampers is specified in Section 717.5 based on the type of assembly it penetrates.

- Fire Walls. (Section 717.5.1)
- Fire Barriers. (Section 717.5.2)
- Shaft Enclosures. (Section 717.5.3)
- Fire Partitions. (Section 717.5.4)
- Smoke Barriers. (Section 717.5.5)
- Exterior Walls. (Section 717.5.6)
- Smoke Partitions. (Section 717.5.7)

142

Section 717.5.1 - Fire Walls

- Ducts and air transfer openings permitted in fire walls in accordance with Section 706.11 shall be protected with listed **fire dampers** installed in accordance with their listing.
- Where the fire wall serves as a **horizontal exit**, listed **smoke dampers** are also required at those points where any ducts or air transfer openings penetrate the fire wall.



143

Section 717.5.2 - Fire Barriers

- Ducts and air transfer openings that penetrate fire barriers shall be protected with approved **fire dampers** installed in accordance with their listing.
- Ducts and air transfer openings shall not penetrate enclosures for interior exit stairways and ramps and exit passageways except as permitted by Sections 1023.5 and 1024.6, respectively.
- Where the fire barrier serves as a **horizontal exit**, listed **smoke dampers** are also required at those points where any ducts or air transfer openings penetrate the fire barrier.

144

Section 717.5.2 - Exceptions 1, 2 & 3

- Fire dampers are not required at penetrations of fire barriers where:
  1. Penetrations are tested in accordance with ASTM E119 or UL 263 as part of the fire-resistance-rated assembly.
  2. Ducts are used as part of an approved smoke control system in accordance with Section 909 and would interfere with system operation.
  3. Maximum 1-hour wall penetrated by a:
     - Ducted HVAC system (continuous w/26 ga. Steel)
     - In areas other than Group H.
     - The building is sprinklered.

2021 IBC Inspection of Fire-Resistance Rated Walls 145

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Section 717.5.3 - Shaft Enclosures

- Shaft enclosures that are permitted to be penetrated by ducts and air transfer openings shall be protected with approved **fire and smoke dampers** installed in accordance with their listing.

2021 IBC Inspection of Fire-Resistance Rated Walls 146

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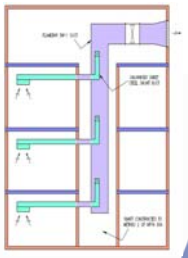
Section 717.5.3 - Exception 1 – Shaft Enclosures

1. **Fire dampers** are not required at penetrations of shafts where:

   1.1 Steel exhaust subducts extend at least **22"** vertically in exhaust shafts provided there is continuous airflow upward to the outside.

   1.2 Penetrations are tested in accordance with ASTM E119 or UL 263 as part of the rated assembly.



2021 IBC Inspection of Fire-Resistance Rated Walls 147

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Section 717.5.3 - Exception 1

1.3 Ducts are used as part of an approved smoke control system designed and installed in accordance with Section 909, and where the fire damper will interfere with the operation of the smoke control system; or

1.4 The penetrations are in parking garage exhaust or supply shafts that are separated from other building shafts by not less than **2-hr.** fire-resistance-rated construction.

2021 IBC Inspection of Fire-Resistance Rated Walls 148

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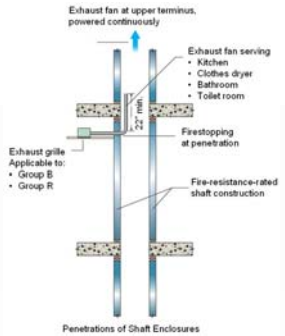
Section 717.5.3 - Exception 2

Exception 2 eliminates smoke damper requirement.



2021 IBC Inspection of Fire-Resistance Rated Walls 149

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Section 717.5.3 - Exceptions 3 & 4

- **Smoke dampers** are not required at penetration of exhaust or supply shafts in parking garages that are separated from other building shafts by not less than **2-hr.** fire-resistance-rated construction.
- **Smoke dampers** are not required at penetrations of shafts where ducts are used as part of an approved mechanical smoke control system designed in accordance with Section 909 and where the smoke damper will interfere with the operation of the smoke control system.

2021 IBC Inspection of Fire-Resistance Rated Walls 150

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Section 717.5.3 - Exception 5

- Fire dampers and combination fire/smoke dampers are not required in kitchen and clothes dryer exhaust systems installed in accordance with the IMC.

151

Section 717.5.4 - Fire Partitions

- Ducts and air transfer openings that penetrate fire partitions shall be protected with listed **fire dampers** installed in accordance with their listing.

152

Section 717.5.4 – Exceptions 1 & 2

In occupancies other than Group H, **fire dampers** are not required where any of the following apply:

1. Corridor walls in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2 and the duct is protected as a through penetration in accordance with Section 714. (Notice this only exempts fire damper. Smoke damper is still required.)
2. Tenant partitions in covered mall buildings where the walls are not required by provisions elsewhere in the code to extend to the underside of the floor or roof deck above.

153

Section 717.5.4 – Exceptions 3 & 4

3. Duct systems of approved materials and the duct penetrating the wall meets all of the minimum requirements.
4. Wall is penetrated by:
   - Ducted HVAC system;
   - In areas other than Group H;
   - The building is sprinklered; and
   - Wall rating of 1-hour or less.

154

Section 717.5.4.1 – Corridors

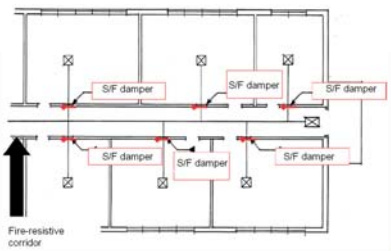
Ducts and air transfer openings that penetrate corridors shall be protected with dampers as follows:

- **Corridor damper** – Where ceiling constructed using 708.4 Exception 3 (tunnel construction).
- **Ceiling radiation damper** – Where ceiling membrane is part of a rated assembly.
- **Smoke damper** – Where penetrating corridor enclosure that requires smoke-and-draft control doors.

155

Section 717.5.4.1 – Corridors

Fire-resistant Corridor in a Non-sprinklered Building.



156

Section 717.5.4.1 – Exception 2

- **Smoke dampers** are not required at the point a duct or air transfer opening penetrates a corridor where the:
  - Building is equipped with a smoke control system.
  - Duct is constructed of steel not less than **0.019" (26 gage steel; 28 gage galvanized)** in thickness and there are no openings serving the corridor.

157

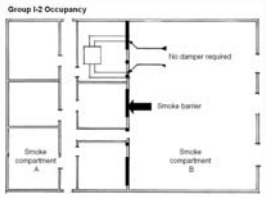
Section 717.5.5 – Smoke Barriers

- Listed smoke damper to be provided at each point a duct or air transfer opening penetrates a smoke barrier.

158

Section 717.5.5 - Smoke Barriers

- Listed smoke damper to be provided at each point a duct or air transfer opening penetrates a smoke barrier.



Exceptions:
1. Where openings in duct are limited to a single smoke compartment and duct is constructed of steel
2. I-2, Condition 2 with ducted HVAC system and quick response sprinklers

159

Section 717.5.6 - Exterior Walls

- Ducts and air transfer openings in fire-resistance-rated exterior walls required to have protected openings in accordance with Section 705.10 shall be protected with listed fire dampers installed in accordance with their listing.

160

Damper Inspection Issues

- Dampers must be installed in accordance with their listing. Get and review manufacturer's installation instructions.
- Verify access is provided per Section 717.4.
- Verify proper type of damper being used and is installed in the correct direction.
- Breakaway connections provided on ductwork.
- Proper gap and support brackets provided around damper. (See manufacturer's instructions)

161

Closing Comments - "Recipe"

- It is only through the proper construction and protection of openings or penetrations that a fire-resistance rated assembly can do what it is intended to do.
- If one aspect is done incorrectly it can compromise the integrity of the assembly and lead to it not doing its intended job.
- So verify construction, continuity and protection of openings of all fire-resistance-rated walls.

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Questions?

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Copyright Materials

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166

File Attachments for Item:

EC-3 2021 IBC Means of Egress (ICC)

All certifications (4 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 IBC Means of Egress

Course instructor: Doug Thornburg

Course description: This session addresses the fundamental concepts and provisions in the IBC pertaining to establishing a compliant means of egress system in buildings. The course deals with both the egress design and egress component provisions, with a focus on the exit access design requirements. Topic include the determination of occupant loads, egress distribution, common path of egress travel, egress illumination and exit signs, interior exit stairways, corridors and exit passageways.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: May 2, 2023 / Tampa Bay, FL

Special Content:

Code Administration:_____

Existing Buildings: _____

Electrical Instruction: _____

Plumbing Instruction:_____

Conference Course: 2021 IBC Means of Egress

Conference Name: ICC Spring Interchange

Conference location: Tampa Bay, FL

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

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Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2021 Means of Egress

Description

This seminar addresses the fundamental concepts and provisions in the International Building Code (IBC) pertaining to establishing a compliant means of egress system in buildings. The course deals with both the egress design and egress component provisions, with a focus on the exit access design requirements. Topic include the determination of occupant loads, egress distribution, common path of egress travel, egress illumination and exit signs, interior exit stairways, corridors and exit passageways

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Goal

The goal of *2021 Means of Egress* is to familiarize building officials, fire officials, plans examiners, inspectors, design professionals, contractors, and others in the design and construction industry with the important design and component requirements of the IBC related to the means of egress system.

Objectives

Upon completion of this seminar, participants will be better able to:

- Understand the basic concepts regarding a means of egress system.
- Identify the requirements applicable to the design of a complying means of egress.
- Identify the requirements applicable to those components commonly found along the means of egress path.

Outline of Seminar **(4 hours = 240 minutes)**

1) Course overview (10 minutes)
   a) Introductions (5)
   b) Objectives (5)

2) Means of egress basics (20 minutes)
   a) Definition of means of egress (10)
   b) Three parts of egress path (10)

3) Occupant loads (40 minutes)
   a) Calculations (20)
   b) Decreasing and increasing occupant load (10)
   c) Cumulative occupant load (5)
   d) Outdoor areas (5)

4) Minimum width and capacity (30 minutes)
   a) Component width (5)
   b) Calculated width (10)
   c) Stairway egress convergence (10)
   d) Distribution of egress capacity (5)

5) Number of exits (35 minutes)
   a) Common path of egress travel (10)
   b) Number of doors determination (5)
   c) Single exit rooms (10)
   d) Single exit stories (10)

6) Arrangement of egress elements (35 minutes)
   a) Separation of exits (10)
   b) Egress through intervening spaces (15)
   c) Travel distance (5)
   d) Dead-end corridors (5)

7) Egress illumination and exit identification (25 minutes)
   a) Exit sign locations (10)
   b) Exit sign illumination (5)
   c) Emergency lighting (10)

8) Corridors and exit passageways (20 minutes)
   a) Width and capacity (10)
   b) Fire-resistance (10)

9) Stairways (20 minutes)
   a) Exit access stairways (5)

b) Interior exit stairways (10)
c) Exterior exit stairways (5)

10) Summary and Wrap-up (5 minutes)

Jay Woodward,
International Code Council

Jay is a Senior Staff Architect with ICC's Business and Product Development department and works out of the Lenexa, Kansas Distribution Center. His primary responsibility is the development of new ICC publications and instructing seminars. Among the publications he has authored or co-authored are the *Significant Changes* books on the IBC, IMC and A117.1 standard, and the recent ICC book *Firestopping, Joint Systems and Dampers*.

With over 30 years of experience in building design, construction, code enforcement and instruction, Jay's experience provides him with the ability to communicate effectively on issues of code application and design for code enforcement personnel as well as architects and designers. Jay has previously served as the secretariat for the ICC A117.1 standard committee, ICC's Energy Conservation Code and the *International Building Code's* Fire Safety Code Development committee.

ICC SPRING INTERCHANGE

2021 IBC Means of Egress

Based on the 2021 International Building Code® (IBC®)

1

Education Sessions

Sponsored By

2

Goal

- Participants will receive an overview of the fundamental requirements for means of egress as established in the 2021 *International Building Code*® (IBC®).
- Upon completion of this course, participants will be able to apply provisions of the 2021 IBC specifically related to the design, plan review and inspection of the means of egress system in commercial buildings.

3

Objectives

- List and describe each of the three parts of a means of egress.
- Calculate the occupant load and determine the required means of egress capacity for rooms, stories and buildings.
- Determine the required number of exit access doorways and exits for rooms, stories and buildings.
- Determine requirements for locations and illumination levels of means of egress lighting and signage.

4

Objectives

- Determine the requirements for arrangement of the means of egress elements, including:
  - Location of exit access doorways and exits.
  - Exit access travel distances.
  - Common paths of egress travel.
  - Egress through adjoining spaces.
- Determine the requirements for means of egress components including corridors, stairways and exit passageways.

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ICC SPRING INTERCHANGE

Means of Egress Basics

Module 1

6

Means of Egress Basics in the IBC

Administration and Maintenance and Plans
- 1001 - 1002

General Means of Egress
- 1003 - 1015

Components of Means of Egress
- Exit Access 1016 - 1021
- Exits 1022 - 1027
- Exit Discharge 1028 - 1029

Miscellaneous
- Assembly 1030
- Emergency Escape and Rescue 1031

7

Definition of MEANS OF EGRESS

- A "Means of Egress":
  - Continuous and unobstructed path of egress travel
  - Vertical and/or horizontal travel
  - Starts at any occupiable portion of a building or structure
  - Ends at public way

8

Three Parts of a Means of Egress

- A means of egress consists of three separate and distinct parts:
  - Exit access
  - Exit
  - Exit discharge
- While typically utilized as an organizational tool, the three-part means of egress concept also provides scoping, such as:
  - Extent of common path of egress travel
  - End point of travel distance measurement

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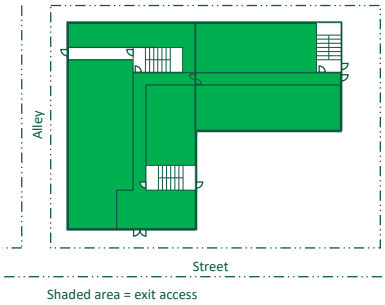
Exit Access



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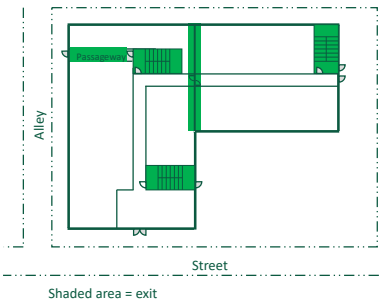
Exit



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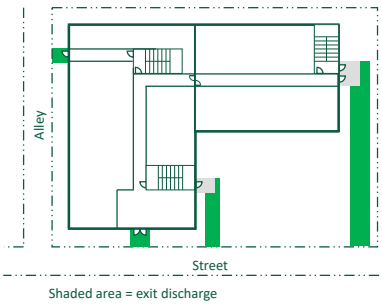
Exit Discharge



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ICC SPRING INTERCHANGE

Occupant Load

Module 2

13

Occupant Load (OL) Section 1004

- Occupant load is used throughout the IBC to determine the application of a provision, particularly when addressing:
  - Means of egress
  - Fire protection features
  - Occupancy classification
  - Plumbing fixture count
- Occupant load is determined based on:
  - Fixed seating conditions, or
  - Conditions where fixed seating is not provided.

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Occupant Load (OL) Section 1004

- In areas with fixed seating—OL is based on seating capacity. Section 1004.6
  - For areas having fixed seating without dividing arms, such as benches and pews, occupant load to be based on one person for each 18 inches of seating length
  - For seating in booths, occupant load to be based on one person for each 24 inches of booth seat length
    - Measurement to be taken at backrest of booth

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Occupant Load (OL) Section 1004

- In areas without fixed seating—OL computed at the rate of one occupant per unit of area. Section 1004.5
- Table 1004.5 identifies maximum floor area allowances per occupant for areas without fixed seating.
  - The determination of occupant load is based upon:
    - Gross floor area, or
    - Net floor area

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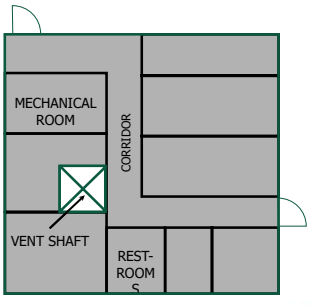
Definition Section 202

- Floor area, *gross*
- Shaded area indicates the portion included in the gross floor area



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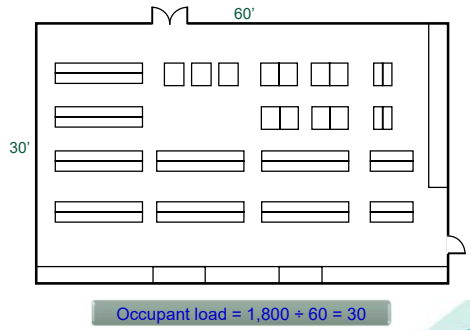
Retail Sales/Mercantile



Occupant load = 1,800 ÷ 60 = 30

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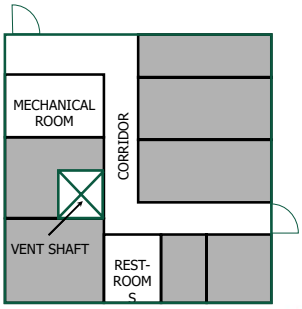
Definition
Section 202

- Floor area, *net*
- Shaded area indicates the portion included in the net floor area



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Maximum Floor Area Allowances per Occupant
Table 1004.5

TABLE 1004.5
MAXIMUM FLOOR AREA ALLOWANCES PER OCCUPANT

FUNCTION OF SPACE	OCCUPANT LOAD FACTOR[a]
Accessory storage areas, mechanical equipment room	300 gross
Agricultural building	300 gross
Aircraft hangars	500 gross
Airport terminal	
Baggage claim	20 gross
Baggage handling	300 gross
Concourse	100 gross
Waiting areas	15 gross
Assembly	
Gaming floors (keno, slots, etc.)	11 gross
Exhibit gallery and museum	30 net
Assembly with fixed seats	See Section 1004.6
Assembly without fixed seats	
Concentrated (chairs only—not fixed)	7 net
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Bowling centers, allow 5 persons for each lane including 15 feet of runway, and for additional areas	7 net
Business areas	150 gross
Concentrated business use areas	See Section 1004.8
Courtrooms—other than fixed seating areas	40 net
Day care	35 net
Dormitories	50 gross
Educational	
Classroom area	20 net
Shops and other vocational room areas	50 net
Exercise rooms	50 gross
Group H-5 fabrication and manufacturing areas	200 gross
Industrial areas	100 gross
Institutional areas	
Inpatient treatment areas	240 gross
Outpatient areas	100 gross
Sleeping areas	120 gross
Kitchens, commercial	200 gross
Library	
Reading rooms	50 net
Stack area	100 gross
Locker rooms	50 gross
Mall buildings—covered and open	See Section 402.8.2
Mercantile	60 gross
Storage, stock, shipping areas	300 gross
Parking garages	200 gross
Residential	200 gross
Skating rinks, swimming pools	
Rink and pool	50 gross
Decks	15 gross
Stages and platforms	15 net
Warehouses	500 gross

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Occupant Load (OL)
Section 1004.5, Exception; 1004.5.1

- The occupant load as calculated based on Table 1004.5 may be decreased to better represent the maximum anticipated number of occupants.
  - Reduction in calculated occupied load permitted where:
    - Approved by building official, and
    - Actual number of occupants can be determined.

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Occupant Load (OL)
Section 1004.5.1

- In addition, the occupant load as calculated based on Table 1004.5 may be increased to better represent the maximum anticipated number of occupants.
  - Increase in calculated occupant load permitted where:
    - All code requirements met based on modified number, and
    - Occupant load does not exceed one occupant per 7 net square feet, and
    - Approved aisle, seating or fixed equipment diagram submitted when required by building official.

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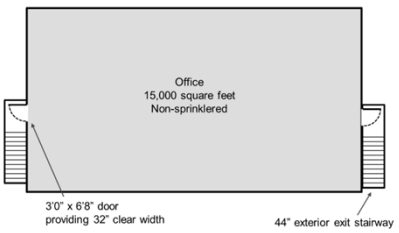
Increased Occupant Load
Section 1004.5.1

EXAMPLE:



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Occupant Load (OL)
Section 1004.2

- The cumulative occupant load is to be determined in accordance with IBC Section 1004.2:
  - Where occupants pass through intervening rooms—OL is cumulative for spaces along egress path. Section 1004.2.1
    - Design of egress path capacity to be based on cumulative portion of occupant loads of all rooms, areas or spaces to that point along the path.
  - Where occupants on a mezzanine egress through an adjacent floor level—OL is cumulative for that level and the mezzanine(s) exiting through that level. Section 1004.2.2
  - Where stairways serve adjacent stories, the occupant load from separate stories is not to be added. Sections 1004.2.3 and 1005.6.

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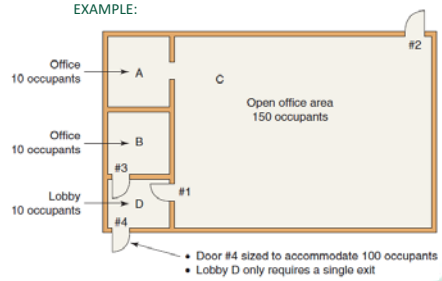
Design Occupant Load
Section 1004.2.1

EXAMPLE:



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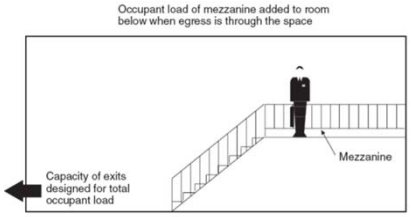
Adjacent Levels for Mezzanines
Section 1004.2.2



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Occupant Load (OL)
Sections 1004.3, 1004.4

- Where areas contains multiple functions having different occupant load factors, design occupant load to be based on area of each function calculated independently.
- Where two or more occupancies utilize portions of the same means of egress system, all components to meet the more stringent requirements of occupancies served.

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Occupant Load (OL)
Section 1004.7

- Yards, patios, occupied roofs courts and similar outdoor areas usable by building occupants to be provided with means of egress per Chapter 10.
  - Occupant load to be based on anticipated use.
  - Where outdoor areas are used by persons in addition to building occupants, and egress path from outdoors passes through building, means of egress requirements to be based on sum of occupant loads.

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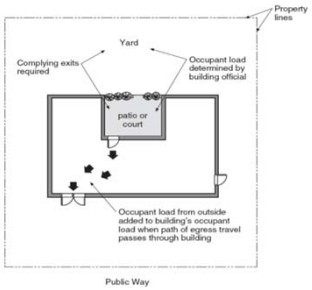
Outdoor Areas
Section 1004.7



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ICC SPRING INTERCHANGE

Means of Egress Minimum Width and Required Capacity

Module 3

30

Minimum Width vs. Required Capacity Section 1005

- All portions of means of egress to be sized per Section 1005, except:
  - Aisles and aisle accessways in assembly rooms and spaces complying with Section 1030.
- Minimum size of egress system to be based upon the greater of:
  - Component width (minimum width), and
  - Calculated width (required capacity)

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Minimum Width vs. Required Capacity Section 1005

- "Minimum width" is based on specific component under consideration, such as:
  - Aisles and corridors: Table 1020.2
  - Doorways: Section 1010.1.1
  - Stairways: Section 1011.2
- "Required capacity" is determined through calculations per Section 1005.3.

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Required Egress Capacity: Other Than Stairways Section 1005.3.2

- Required capacity of all egress components other than stairways, including doors, ramps, aisles and corridors:
  - Occupant load served multiplied by 0.2"
  - For other than Group H and I-2, the required capacity is occupant load served multiplied by 0.15" ***IF***
    - Building is equipped with an emergency voice/alarm communication system ***and***
    - Building is equipped with an automatic fire sprinkler system (NFPA 13 or 13R)

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Required Egress Capacity: Stairways Section 1005.3.1

- Required capacity for stairways only:
  - Occupant load served multiplied by 0.3"
  - For other than Group H and I-2, the minimum width is occupant load served multiplied by 0.2" ***IF***
    - Building is equipped with an emergency voice/alarm communication system ***and***
    - Building is equipped with an automatic fire sprinkler system (NFPA 13 or 13R)

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Stairway Capacity and Egress Convergence Sections 1005.3.1, 1005.6

- Required capacity for the egress stairway shall be determined based solely on the occupant load of the adjacent story served by the stairway
- Where egress from stories above and below converge at an intermediate level, the capacity from point of convergence to be ≥ sum of the stairway capacities for two adjacent stories

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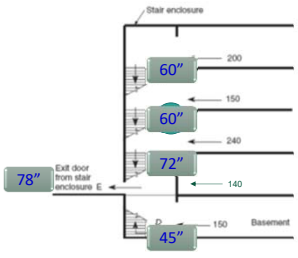
Stairway Capacity and Egress Convergence Sections 1005.3.1, 1005.6



ASSUME: Stairway serving occupant loads in office building as shown. Building is sprinklered throughout but has no EV/AC system.

DETERMINE: Minimum stairway widths for stairway segments A-D and doorway width E, based on:

- 0.3"/person for stairways
- 0.2"/person for doorway

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Required Egress Width and Capacity Continuity Section 1005.4

- Minimum width or required capacity required from any story shall not be reduced along the path of egress travel until arrival at the public way.

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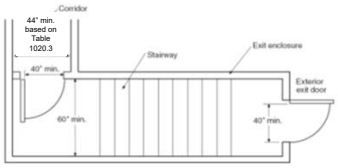
Application Example

- Sprinklered building, but no EV/AC system
- Group B occupancy
- Corridor serves 400 occupants and connects two interior exit stairways.

200 (occupants) x 0.3 (stairs) = 60" exit width

200 (occupants) x 0.2 (other egress) = 40" exit width



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Distribution of Minimum Width and Required Capacity Section 1005.5

- Multiple means of egress shall be sized such that the loss of any one means of egress will not reduce the available capacity or width to less than 50 percent of the required capacity or width.

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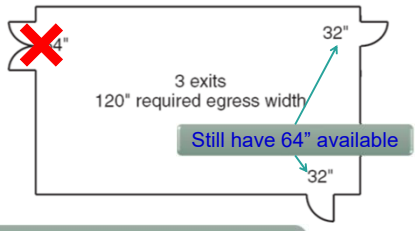
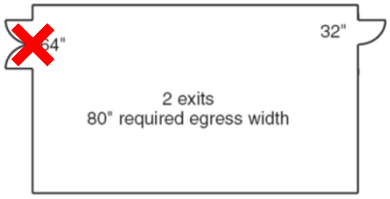
Application Example



OK: The loss of any single exit will not result in less than half of required width or capacity remaining

40

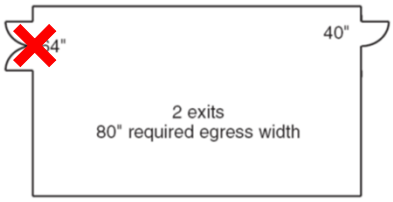
Application Example



Not permitted: Loss of a single exit could result in less than half of required width or capacity remaining.

41

Application Example



OK: Although double doors give greater than half of available width or capacity, not less than half of required width or capacity would still remain.

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Number of Exits and Exit Access Doorways

Module 4

43

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Egress from Spaces Section 1006.2

- Two exits or exit access doorways are required from a space where:
  - The occupant load of the space exceeds the number shown in Table 1006.2.1, or
  - The common path of travel exceeds the limitations set forth in Table 1006.2.1.

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Common Path of Egress Travel Sections 202, 1006.2

- COMMON PATH OF EGRESS TRAVEL.

  That portion of the exit access travel distance measured from the most remote point within a story to that point where the occupants have separate and distinct access to two exits or exit access doorways.

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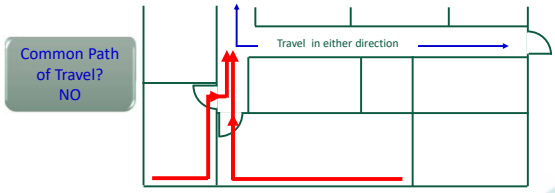
Common Path of Egress Travel Sections 202, 1006.2



Common path of egress travel ends where there is choice of separate access to two exits or exit access doorways.

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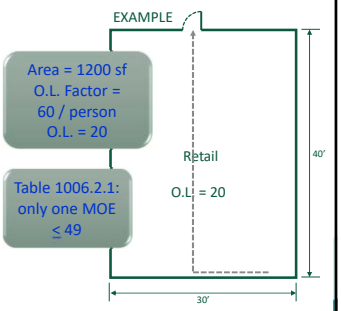
Minimum Number of Exits or Exit Access Doorways Section 1006.2.1

- Every space shall have access to at least one MOE
- Two MOE when the occupant load is above the threshold in Table 1006.2.1
- Two MOE when the common path of travel is exceeded



Allowable Common Path of Travel = 75'

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Spaces with One Exit or Exit Access Doorway Table 1006.2.1

TABLE 1006.2.1
SPACES WITH ONE EXIT OR EXIT ACCESS DOORWAY

OCCUPANCY	MAXIMUM OCCUPANT LOAD OF SPACE	MAXIMUM COMMON PATH OF EGRESS TRAVEL DISTANCE (feet)		
		Without Sprinkler System (feet)		With Sprinkler System (feet)
		Occupant Load		
		OL ≤ 30	OL > 30	
A', E, M	49	75	75	75'
B	49	100	75	100'
F	49	75	75	100'
H-1, H-2, H-3	3	NP	NP	25'
H-4, H-5	10	NP	NP	75'
I-1, I-2', I-4	10	NP	NP	75'
I-3	10	NP	NP	100'
R-1	10	NP	NP	75'
R-2	20	NP	NP	125'
R-3'	20	NP	NP	125'*
R-4'	20	NP	NP	125'*
S'	29	100	75	100'
U	49	100	75	75'

For SI: 1 foot = 304.8 mm.
NP = Not Permitted.

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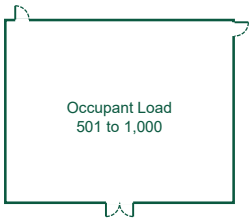
Minimum Number of Exits
Section 1006.2.1.1

- Three exits or exit access doorways to be provided from any space where occupant load is 501 to 1,000



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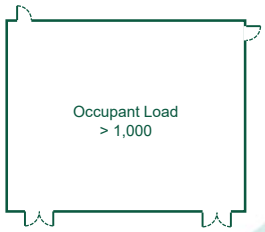
Minimum Number of Exits
Section 1006.2.1.1

- Minimum of four exits or exit access doorways required from any space where occupant load > 1,000



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Minimum Number of Exits from Stories and Occupied Roofs
Section 1006.3.3

- Each story and occupied roof to have minimum number of exits, or access to exits, as set forth in Table 1006.3.3.

TABLE 1006.3.3
MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS PER STORY

OCCUPANT LOAD PER STORY	MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS FROM STORY
1-500	2
501-1,000	3
More than 1,000	4

51

Single Exit Stories
Section 1006.3

- A single exit or access to a single exit permitted where in compliance with Table 1006.3.4(1) or 1006.3.4(2)

TABLE 1006.3.4(1)
STORIES WITH ONE EXIT OR ACCESS TO ONE EXIT FOR R-2 OCCUPANCIES

STORY	OCCUPANCY	MAXIMUM NUMBER OF DWELLING UNITS	MAXIMUM EXIT ACCESS TRAVEL DISTANCE
Basement, first, second or third story above grade plane	R-2[a, b]	4 dwelling units	125 feet
Fourth story above grade plane and higher	NP	NA	NA

For SI: 1 foot = 304.8 mm.
NP = Not Permitted.
NA = Not Applicable.
a. Buildings classified as Group R-2 equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2 and provided with emergency escape and rescue openings in accordance with Section 1031.
b. This table is used for R-2 occupancies consisting of dwelling units. For R-2 occupancies consisting of sleeping units, use Table 1006.3.4(2).

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Single Exit Stories
Section 1006.3

- A single exit or access to a single exit permitted where in compliance with Table 1006.3.4(1) or 1006.3.4(2)

TABLE 1006.3.4(2)
STORIES WITH ONE EXIT OR ACCESS TO ONE EXIT FOR OTHER OCCUPANCIES

STORY	OCCUPANCY	MAXIMUM OCCUPANT LOAD PER STORY	MAXIMUM EXIT ACCESS TRAVEL DISTANCE (feet)
First story above or below grade plane	A, B[b], E, F[b], M, U	49	75
	H-2, H-3	3	25
	H-4, H-5, I, R-1, R-2[a, c]	10	75
	S[b, d]	29	75
Second story above grade plane	B, F, M, S[b]	29	75
Third story above grade plane and higher	NP	NA	NA

For SI: 1 foot = 304.8 mm.
NP = Not Permitted.
NA = Not Applicable.
a. Buildings classified as Group R-2 equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2 and provided with emergency escape and rescue openings in accordance with Section 1031.
b. Group B, F and S occupancies in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 shall have a maximum exit access travel distance of 100 feet.
c. This table is used for R-2 occupancies consisting of sleeping units. For R-2 occupancies consisting of dwelling units, use Table 1006.3.4(1).
d. The length of exit access travel distance in a Group S-2 open parking garage shall be not more than 100 feet.

53

Arrangement of Means of Egress Elements

Module 5

54

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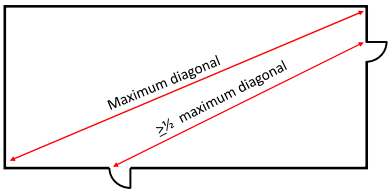
Design of Exit Access Elements

- Once the egress capacity and number of required egress elements is determined, the following provisions must be addressed:
  - Separation of multiple exits and/or exit access doorways. Section 1007
  - Means of egress travel through intervening spaces. Section 1016.2
  - Exit access travel distance limitations. Section 1017
  - Dead-end corridor conditions. Section 1020.5

55

Exit or Exit Access Doorway Arrangement Section 1007.1.1

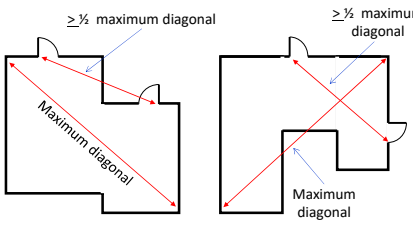
- Where two exits or exit access doorways are required, they are to be separated a minimum distance of ½ of the maximum overall diagonal dimension of the building or area served.



56

Exit or Exit Access Doorway Arrangement Section 1007.1.1

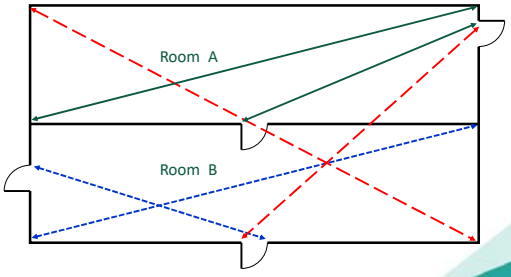
- All measurements to be taken in a straight line.



57

Exit or Exit Access Doorway Arrangement Section 1007.1.1

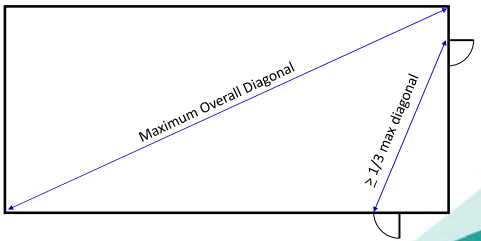
- Both building and areas served to be regulated



58

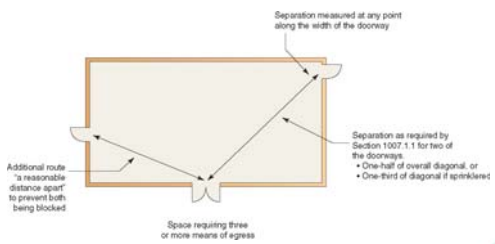
Exit or Exit Access Doorway Arrangement Section 1007.1.1, Exception 2

- Exception 2 recognizes that when the building is fully sprinklered, the minimum required separation distance may be reduced to 1/3 the maximum overall diagonal.



59

Exit or Exit Access Doorway Arrangement Section 1007.1.2



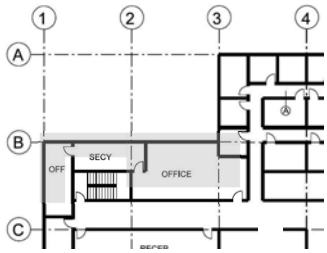
60

Egress Through Intervening Spaces
Section 1016.2, #2

- Egress from or room or space shall not pass through an adjoining room or space except where:
  - Intervening rooms are related to the area or room served, and
  - Intervening room is not a Group H occupancy, and
  - Path of egress travel is clear and discernible to an exit
- Intervening rooms cannot have potential to be locked to prevent egress

61

Egress Through Intervening Spaces
Section 1016.2, #2

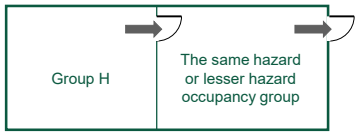


Common Path of Egress Travel becomes limiting factor

62

Egress Through Intervening Spaces
Section 1016.2, #2, Exception

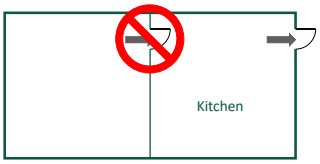
- In Group H occupancies, travel through intervening rooms of the same or lesser hazard occupancy group is permitted.



63

Egress Through Intervening Spaces
Section 1016.2, #5

- Egress travel shall not pass through kitchens, storerooms, closets or spaces used for similar purposes

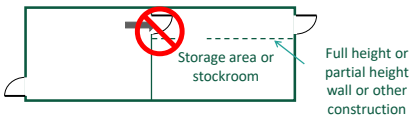


Only allowed ***IF*** the kitchen is part of the dwelling unit or sleeping area

64

Egress Through Intervening Spaces
Section 1016.2, #5, Exception 2

- Egress travel through stockrooms in Group M permitted where four conditions are met:



Only allowed in Group M if:
- not able to be locked from egress side
- physical demarcation of minimum 44" egress path
- serves maximum of 50% of exits
- stock is of same hazard classification as in sales area

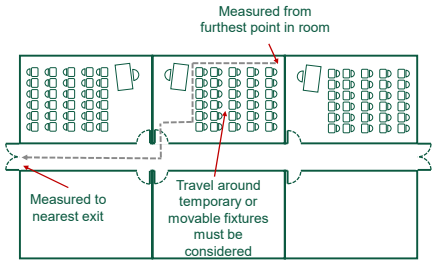
65

Exit Access Travel Distance
Section 1017.3

- Travel distance is limited within the exit access portion of the means of egress.
- Travel distance is measured:
  - **From** the most remote point of each room, area or space
  - **Along** a natural unobstructed path of vertical and horizontal egress travel
  - **To** the entrance of an exit.
- Where two or more exits are required, travel limits are based on the nearest exit.

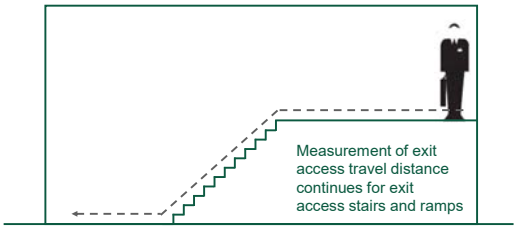
66

Exit Access Travel Distance
Section 1017.3



67

Exit Access Travel Distance
Section 1017.3.1



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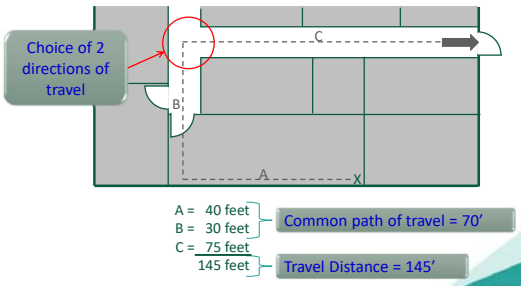
Travel Distance Measurement

- Measurement is to ''nearest' exit



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Exit Access Travel Distance
Table 1017.2

TABLE 1017.2
EXIT ACCESS TRAVEL DISTANCE[a]

OCCUPANCY	WITHOUT SPRINKLER SYSTEM (feet)	WITH SPRINKLER SYSTEM (feet)
A, E, F-1, M, R, S-1	200[e]	250[b]
I-1	Not Permitted	250[b]
B	200	300[c]
F-2, S-2, U	300	400[c]
H-1	Not Permitted	75[d]
H-2	Not Permitted	100[d]
H-3	Not Permitted	150[d]
H-4	Not Permitted	175[d]
H-5	Not Permitted	200[c]
I-2, I-3	Not Permitted	200[c]
I-4	150	200[c]

For SI: 1 foot = 304.8 mm.

70

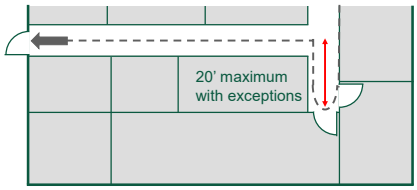
Travel Distance Increase for Group F-1 and S-1 Occupancies
Section 1017.2.2

- Maximum travel distance of 400 feet permitted in Group F-1 and S-1 occupancies where:
  - Portion of building classified as Group F-1 or S-1 limited to one story in height, and
  - Minimum floor to ceiling/roof deck height is 24 feet, and
  - Building is fully sprinklered.

71

Dead Ends in Corridors
Section 1020.5

- Where **more than one exit or exit access doorway is required** from a corridor, dead-ends within the corridor system are limited in length.
- General limitation on dead-end corridors is 20 feet in length.



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Dead Ends in Corridors
Section 1020.5, Exceptions

- Where building is fully sprinklered (NFPA 13 system only), maximum dead conditions of 50 feet are permitted in Group B, E, F, I-1, M, R-1, R-2, S and U occupancies
- Maximum of 50 feet permitted in Group I-3 occupancies classified as Condition 2, 3 or 4
- Maximum of 30 feet permitted in Group I-2, Condition 2 occupancies where dead-end corridors do not serve patient rooms or patient treatment spaces
- Unlimited length permitted where the length of the dead-end corridor is less than 2.5 times the least width of the dead-end corridor.

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ICC SPRING INTERCHANGE

Egress Illumination and Exit Signs

Module 6

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Exit Signs
Section 1013.1

- Exits signs required:
  - At exit and exit access doors
  - Where necessary to clearly indicate direction of egress travel in cases where exit or path of travel not immediately visible to occupants
- In addition, exit signage to be located:
  - At intervening means of egress doors within exits
  - In corridors and exit passageways such that every point is within 100 feet of the nearest visible sign
    - Reduced distance where required by listed viewing distance of sign

75

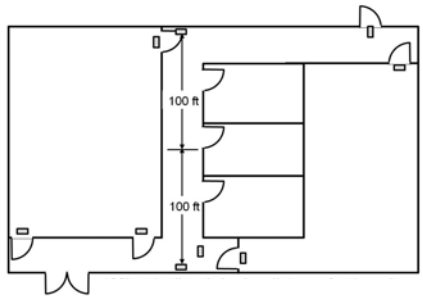
Exit Signs
Section 1013.1, Exceptions

Exit signs not required in:

1. Rooms or areas with one exit or exit access
2. Main exterior exit doors that are clearly identifiable as exits where approved by the building official
3. Group U occupancies and individual sleeping units or dwelling units in Groups R-1, R-2 or R-3 occupancies
4. Sleeping areas in Group I-3 occupancies
5. Group A-4 and A-5 occupancies on the seating side of vomitories

76

Exit Signs
Location Activity



77

Illumination of Exit Signs
Sections 1013.3, 1013.6

- Exit signs to be externally or internally illuminated at all times
  - Not applicable to tactile signs
- Electrically-powered, self-luminous and photoluminescent exit signs to be listed and labeled in accordance with UL 924.

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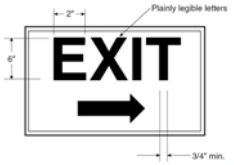
Externally Illuminated Exit Signs
Section 1013.6

- The word "EXIT" to be in high contrast with background and must be clearly discernable.
- Face of sign to be illuminated from an external source with minimum intensity of 5 footcandles.
- Illumination required for a minimum of 90 minutes after power loss.



79

Means of Egress Illumination
Section 1008.2

- The means of egress serving a room or space to be illuminated at all times the room or space is occupied, except for:
  - Group U occupancies
  - Aisle accessways in Group A
  - Group R-1, R-2 and R-3 dwelling units and sleeping units
  - Group I sleeping units
- Minimum illumination level to be at least:
  - One footcandle at walking surface
  - Ten footcandles along exit access stairways, exit stairways and their required landings

80

Emergency Power for Illumination
Section 1008.3

- The power supply for means of egress illumination to be provided by the premises' electrical system.
- In the event of power failure, an emergency electrical system shall automatically illuminate specified areas.
- Emergency power to be provided for ≥ 90 minutes by:
  - Storage batteries
  - Unit equipment
  - On-site generator

81

Emergency Power for Illumination
Section 1008.3

- Where power failure occurs in rooms or spaces that require two or more exits or access to exits, the following areas to be automatically illuminated:
  - Aisles
  - Corridors
  - Exit access stairways and ramps

82

Emergency Power for Illumination
Section 1008.3

- Where power failure occurs in buildings that require two or more exits or access to exits, the following areas to be automatically illuminated:
  - Interior exit access stairways and ramps
  - Interior exit stairways and ramps
  - Exterior exit stairways and ramps
  - Vestibules and other interior exit discharge areas
  - Exterior landings for exit doorways that lead directly to the exit discharge

83

Emergency Power for Illumination
Section 1008.3.5

- Emergency lighting facilities to provide:
  - Initial illumination providing an average of ≥ 1 footcandle
  - At least 0.1 footcandle at any point
  - A maximum-to-minimum uniformity ratio ≤ 40 to 1.
- Illumination levels permitted to decline during the emergency lighting time duration to:
  - 0.6 footcandle average
  - 0.06 footcandle at any point

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ICC SPRING INTERCHANGE

Corridors and Exit Passageways

Module 7

85

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Corridors vs. Exit Passageways

Feature	Corridor	Exit Passageway
Component of egress	Exit access	Exit
One direction of travel	Possibly (limitations based on length and number of persons served)	Yes (single directional travel typically permitted)
Fire-resistance rated construction	Possibly (constructed as fire partition)	Yes (constructed as fire barrier)
Provides access to storage areas, mechanical rooms, etc.	Yes	No (except in covered mall buildings)
Travel distance regulated	Yes	No
Openings	No limitations (protected as applicable)	Limited to egress doors from normally occupied spaces

2021 IBC Means of Egress

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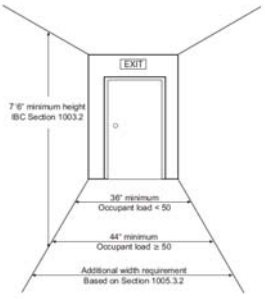
Width and Capacity
Section 1020.3



Additional provisions in Table 1020.3

2021 IBC Means of Egress

87

Minimum Corridor Width
Table 1020.3

TABLE 1020.3
MINIMUM CORRIDOR WIDTH

OCCUPANCY	MINIMUM WIDTH (inches)
Any facility not listed in this table	44
Access to and utilization of mechanical, plumbing or electrical systems or equipment	24
With an occupant load of less than 50	36
Within a dwelling unit	36
In Group E with a corridor having an occupant load of 100 or more	72
In corridors and areas serving stretcher traffic in ambulatory care facilities	72
Group I-2 in areas where required for bed movement	96

For SI: 1 inch = 25.4 mm.

2021 IBC Means of Egress

88

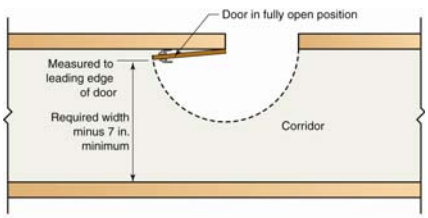
Encroachment
Section 1005.7

- Doors, when fully opened, shall not reduce the required means of egress width by more than 7".
- Doors in any position shall not reduce the required width by more than one-half.
  - **Exception:** The restrictions on a door swing shall not apply to doors within individual dwelling units and sleeping units of Groups R-2 and R-3.
- Other nonstructural projections such as trim and similar decorative features shall be permitted to project into required width a maximum of 1½" on each side.

2021 IBC Means of Egress

89

Encroachment
Section 1005.7



Does not apply to dwelling units and sleeping units

2021 IBC Means of Egress

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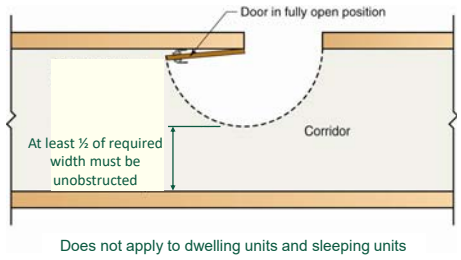
Encroachment
Section 1005.7



Does not apply to dwelling units and sleeping units

91

Corridor Fire-Resistance Rating
Table 1020.2

TABLE 1020.2
CORRIDOR FIRE-RESISTANCE RATING

OCCUPANCY	OCCUPANT LOAD SERVED BY CORRIDOR	REQUIRED FIRE-RESISTANCE RATING (hours)	
		Without sprinkler system	With sprinkler system
H-1, H-2, H-3	All	Not Permitted	1[e]
H-4, H-5	Greater than 30	Not Permitted	1[e]
A, B, E, F, M, S, U	Greater than 30	1	0
R	Greater than 10	Not Permitted	0.5[c]/1[d]
I-2[a]	All	Not Permitted	0
I-1, I-3	All	Not Permitted	1[b, e]
I-4	All	1	0

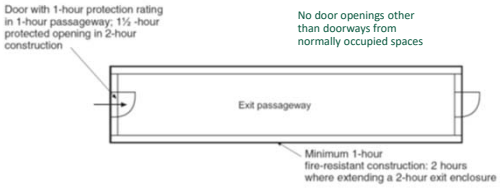
92

Exit Passageways
Section 1024

- Exit passageways to be only used for:
  - Means of egress
  - Circulation path
- Minimum capacity of exit passageways based on Section 1005.1, with minimum width not less that 44 inches (36 inches permitted when serving < 50 occupants)
- Exit passageways to be constructed with minimum 1-hour fire barriers, horizontal assemblies, or both.
  - Minimum 2-hour rating required when exit passageway used as an extension of a 2-hour interior exit stairway.

93

Exit Passageways
Section 1024



*Maximum transmitted temperature ≤ 450°F above ambient at end of 30 minutes of fire test. (Temp. rise not regulated in sprinklered building)

94

Exit Passageways
Section 1024

- Equipment and ductwork for exit passageway ventilation must be independent of other building ventilation systems, and:
  - Be located at the building's exterior and directly connect to the enclosure by ductwork in complying shafts, or
  - When located within the enclosure, receive intake air taken directly from the outdoors and exhaust air directly to the outside, or utilize ducts within complying shafts, or
  - When located within the building, be separated from the remainder of the building, including other mechanical equipment, through the use of complying shafts.

95

Stairways

Module 8

96

Exit Access Stairways
Section 1019.3

- Exit access stairways that serve floor levels within a single story, such as mezzanines, are not required to be enclosed.
- Exit access stairways between stories in Groups I-2 and I-3 to be enclosed by a shaft enclosure.

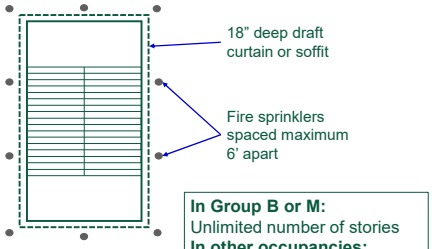
97

Exit Access Stairways
Section 1019.3

- In other than Group I-2 and I-3 occupancies, exit access stairways shall also be enclosed, except:
  - When serving or atmospherically communicating between two stories (such interconnected stories shall not be open to other stories)
  - When connecting ≤ 4 stories within an individual dwelling unit or sleeping unit in a Group R-1, R-2 or R-3 occupancy
  - Within an atrium or open parking garage
  - Between the balcony, gallery or press box and an assembly floor
  - In sprinklered buildings where openings are protected by draft curtains and closely-spaced sprinklers per Exception 4.

98

Exit Access Stairways
Section 1019.3, Exception 4

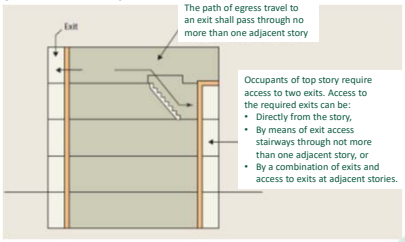


In Group B or M:
Unlimited number of stories
In other occupancies:
Limit of 4 stories connected

99

Egress from Stories and Occupied Roofs
Section 1006.3.2

- With exceptions, the path of egress travel to an exit shall not pass through more than one adjacent story.



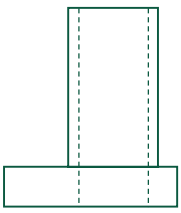
100

Interior Exit Stairways
Section 1023.1

- All interior exit stairways shall be enclosed and:
  - Lead directly to the exterior of the building, or
  - Be extended to the building's exterior by means of an exit passageway, or
  - Comply with Section 1028.2 addressing interior exit discharge.
- Interior exit stairways shall only be used for the following purposes:
  - Means of egress
  - Circulation paths

101

Interior Exit Stairways
Section 1023.2



- Enclosure construction:
  - ≥ 4 stories: Minimum 2-hour fire-resistance
  - < 4 stories: Minimum 1-hour fire-resistance
  - Not less than floor assembly penetrated, but need not be more than 2 hours
- Door assemblies:
  - Self-closing or automatic-closing
  - Minimum 1-hour rating for 1-hour enclosures
  - Minimum 1½-hour rating for 2-hour enclosures

102

Interior Exit Stairway Openings
Section 1023.4

- Opening protectives to comply with Section 716.
- Other than exterior openings permitted to be unprotected, openings in interior exit stairways limited to:
  - Egress doors into the enclosure from normally occupied spaces, and
  - Egress from the enclosure.
- Elevators shall not open into interior exit stairways.

103

Interior Exit Stairway Penetrations
Section 1023.5

- Penetrations into or through interior exit stairways are prohibited except for the following:
  - Equipment and ductwork necessary for independent ventilation or pressurization
  - Fire protection systems
  - Two-way communication systems
  - Electrical raceway for fire department communication systems
  - Electrical raceway serving the stairway (must terminate in a steel box ≤ 16 square inches)
  - Structural elements supporting the stairway enclosure (such as beams or joists)

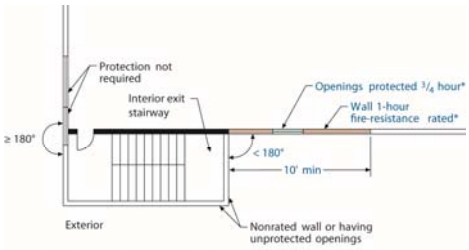
104

Interior Exit Stairway Ventilation
Section 1023.6

- Equipment and ductwork for interior exit stairway ventilation must:
  - Be located at the building's exterior and directly connect to the enclosure by ductwork in complying shafts, or
  - When located within the enclosure, receive intake air taken directly from the outdoors and exhaust air directly to the outside, or utilize ducts within complying shafts, or
  - When located within the building, be separated from the remainder of the building, including other mechanical equipment, through the use of complying shafts.

105

Interior Exit Stairway Exterior Walls
Section 1023.7

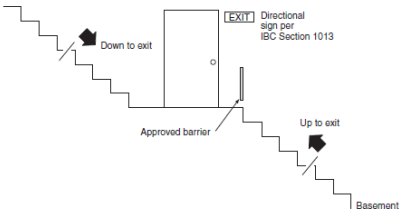


* Protected to a height of 10 feet above topmost landing or roof, whichever is less.

For SI: 1 foot = 304.8 mm, 1°C = [(°F) - 32/1.8]

106

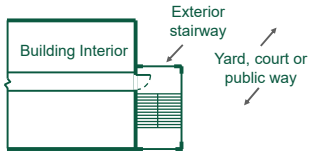
Discharge Identification
Section 1023.8



107

Exterior Exit Stairways
Section 1027.2

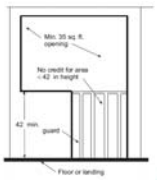
- Exterior exit stairways serving as a portion of the means of egress are:
  - Limited to buildings ≤ 6 stories above grade plane
  - Prohibited for high-rise buildings and Group I-2 occupancies



108

Exterior Exit Stairways
Section 1027.3

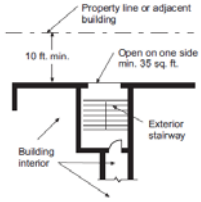
- Exterior exit stairways shall be open on at least one side, except for required structural elements, handrails and guards.
- Openings are to be located at each:
  - Floor level, and
  - Intermediate landings



109

Exterior Exit Stairways
Section 1027.5

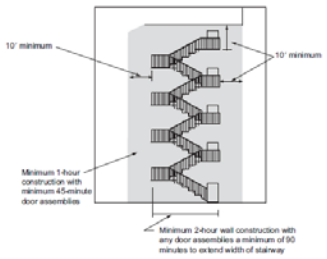
- Exterior exit stairways are to have a minimum fire separation distance of 10 feet from:
  - Adjacent lot lines
  - Other portions of building
  - Other buildings on same lot



110

Exterior Stairways Protection Section 1027.6

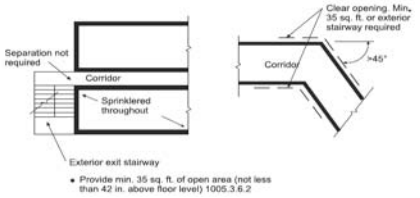
- Exterior exit stairways to be separated from the interior of the building per Section 1023.2.



111

Open-ended Corridors
Section 1027.6, Exception 3

- Separation is not required for complying open-ended corridors.
  - The building, including open-ended corridors and stairways, to be sprinklered throughout.



- Provide min. 35 sq. ft. of open area (not less than 42 in. above floor level) 1005.3.6.2

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Questions?

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Thank you for Attending

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File Attachments for Item:

EC-4 2021 IBC Occupancy Classification and Mixed Occupancies (ICC)

All certifications (4 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

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Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 IBC Occupancy Classification and Mixed Occupancies

Course instructor: Doug Thornburg

Course description: This session covers the key issues of the IBC regarding the proper classification of buildings based on use. In addition to an overview of the specific occupancy classifications, the discussion will include how to address buildings containing two or more occupancies. The three mixed-occupancy options of accessory, nonseparated and separated occupancies are presented along with examples that illustrate the proper application of the provisions.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: May 3, 2023 / Tampa Bay, FL

Special Content:

Code Administration:_____

Existing Buildings: _____

Electrical Instruction: _____

Plumbing Instruction:_____

Conference Course: 2021 IBC Occupancy Classification and Mixed Occupancies

Conference Name: ICC Spring Interchange

Conference location: Tampa Bay, FL

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2021 Occupancy Classification and Mixed Occupancies

Description

This seminar covers the key issues of the International Building Code (IBC) regarding the proper classification of buildings based on use. In addition to an overview of the specific occupancy classifications, the discussion will include how to address buildings containing two or more occupancies. The three mixed-occupancy options of accessory, nonseparated and separated occupancies are presented along with examples that illustrate the proper application of the provisions.

Goal

The goal of *2021 IBC Occupancy Classification and Mixed Occupancies* is to familiarize building officials, fire officials, plans examiners, inspectors, design professionals, contractors, and others in the classification of buildings based on use and how to deal with buildings having multiple occupancy classifications.

Objectives

Upon completion of this seminar, participants will be better able to:

- Identify the 26 occupancy classifications found in the IBC.
- Understand how buildings containing two or more occupancy classifications are regulated.
- Determine how fire protection features and allowable building size are affected based upon which of the three mixed-occupancy methods are applied.

Outline of Seminar **(4 hours = 240 minutes)**

1) Course overview (10 minutes)
   a) Introductions (5)
   b) Objectives (5)

2) Concepts of Occupancy Classification (25 minutes)
   a) Use vs. occupancy (10)
   b) Occupant-related hazards (5)
   c) Content-related hazards (5)
   d) Ten basic classifications (5)

3) Occupancy Classification Groups (85 minutes)
   a) Group A (20)
   b) Group B (5)
   c) Group E (5)
   d) Group F (5)
   e) Group H (10)
   f) Group I (10)
   g) Group M (5)
   h) Group R (15)
   i) Group S (5)
   j) Group U (5)

4) Application of the Mixed Occupancy Methods (15 minutes)
   a) The three options (10)
   b) Conditions where not applicable (5)

5) Nonseparated Occupancies (35 minutes)
   a) Concept and overview of nonseparated method (10)
   b) Fire protection aspects (5)
   c) Allowable height and area (5)
   d) The process (15)

6) Separated Occupancies (40 minutes)
   a) Concept and overview of separated method (10)
   b) Fire protection aspects (5)
   c) Allowable height and area (5)
   d) Fire-resistive separations (5)
   e) The process (15)

7) Accessory Occupancies (25 minutes)
   a) Concept and overview of accessory method (10)
   b) Allowable height and area (5)

c) The process (10)

8) Summary and Wrap-up (5 minutes)

Douglas W. Thornburg, AIA, CBO, is currently Vice-President and Technical Director of Products and Services for the International Code Council (ICC) where he provides administrative and technical leadership for the ICC product development activities. Prior to employment with ICC in 2004, he was in private practice as a code consultant and educator on building codes for nine years. Doug also spent ten years with the International Conference of Building Officials (ICBO) where he served as Vice-President/Education.

In his current role, Doug also continues to create and present building code seminars nationally and has developed numerous educational texts and resource materials. He was presented with ICC's inaugural Educator of the Year Award in 2008, recognizing his outstanding contributions in education and training.

A graduate of Kansas State University and a registered architect, Doug has over 36 years of experience in building code training and administration. He has authored a variety of code-related support publications, including the *IBC Illustrated Handbook* and the *Significant Changes to the International Building Code*.

ICC SPRING INTERCHANGE

2021 IBC Occupancy Classification and Mixed Occupancies

Based on the 2021 International Building Code®

1

Education Sessions

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2

ICC SPRING INTERCHANGE

Introduction

3

Course Description

- This seminar addresses the key issues of the 2021 *International Building Code*® (IBC®) regarding the proper classification of buildings based on use.
- In addition, the application of multiple-occupancy conditions will be discussed.

4

Course Description

- Everything starts with the correct occupancy classification!
- Good decisions in the occupancy classification process provide the groundwork for the proper application of many other important code provisions.

5

Goal

- Participants will be able to:
  - Assign the appropriate occupancy classification(s) based on Chapter 3, and
  - Apply the mixed occupancy provisions of Section 508.

6

Objectives

Upon completion, participants will be better able to:

1. Identify and describe the 26 specific occupancy groups established in the 2021 IBC.
2. Determine how to apply the mixed-occupancy process for accessory occupancies, nonseparated occupancies and separated occupancies.
3. Understand how the mixed-occupancy provisions relate to the requirements for allowable building size and required fire protection features.

7

Occupancy Classification

8

Occupancy Classification—Introduction

Evaluate the building for use and occupancy:

- How the space will be used.
- The abilities of the occupants to respond in an emergency.
- Specific requirements (levels of safety) related to the various occupancy groups.

9

Occupancy Classification—General Requirements Section 302.1

Occupancy Groups

- Structures are to be classified into one or more of the occupancy classifications established in the code.
- The 10 general types are further subdivided into 26 specific occupancies.
  - In addition, three of the specific occupancies are further subdivided into Conditions 1 and 2

10

Occupancy Classification—General Requirements Section 302.1

- Where a room or space is to be occupied for different types of uses at different times, all of the requirements applicable to each of the uses must be considered.
- Those buildings that contain two or more distinct occupancy classifications must comply with the provisions of Section 508 for mixed-occupancy buildings.

11

Use vs. Occupancy

- "Use" and "Occupancy" are terms that differ in meaning and application within the IBC.
- "Use" describes the activity that occurs within the space, room or building.
  - "Use" is seldom utilized in the IBC as the scoping mechanism.
  - Examples include occupant load calculation and incidental uses.
- "Occupancy" describes the specific classification a "use" is assigned when applying the code to a space, room or building.
  - Almost all code provisions with application to a limited number of situations are regulated by "Occupancy".
  - Primary examples include allowable height and area, fire protection features and means of egress requirements.

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Use vs. Occupancy

- Multiple uses do not necessarily create multiple occupancies.
- General occupancy classification is intended to include related support areas such as corridors, stairways, restrooms, mechanical equipment rooms, small storage areas, etc.

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Occupancy Classification—General Requirements Section 302.1

- When in doubt, it is important that an occupancy classification be assigned that most nearly resembles those occupancies with similar fire safety and life safety risks.

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Occupancy Classification

- Occupant-related Hazards
  - Number of occupants.
  - Density of the occupants.
  - Age of the occupants.
  - Mobility of the occupants.
  - Awareness of the occupants.

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Occupancy Classification

- Content-related Hazards
  - Density of contents.
  - Quantity of contents.
  - Type of contents.
  - Environment of contents.
  - Combustibility/Flammability of contents.

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Occupancy Classification — General Requirements Section 302.1

Types of Use	General Occupancy Group	Occupancy Sub-Groups
Assembly	Group A	A-1, A-2, A-3, A-4, A-5
Business	Group B	None
Educational	Group E	None
Factory / Industrial	Group F	F-1, F-2
High Hazard	Group H	H-1, H-2, H-3, H-4, H-5
Institutional	Group I	I-1, I-2, I-3, I-4
Mercantile	Group M	None
Residential	Group R	R-1, R-2, R-3. R-4
Storage	Group S	S-1, S-2
Utility	Group U	None

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Occupancy Classification—Assembly Group A Section 303.1

Assembly Group A occupancies include buildings or portions of buildings where persons (usually 50 or more) gather for:

- Civic, social or religious functions.
- Recreation.
- Food and/or drink consumption.
- Awaiting transportation.
- Similar activities.

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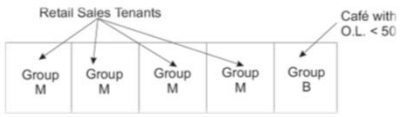
Occupancy Classification—Assembly Section 303.1.1

Small buildings and tenant spaces: Buildings or tenant spaces with an occupant load of 49 or less. The building or space is a stand-alone use and is not accessory to any other occupancy. The classification of Group B is appropriate.

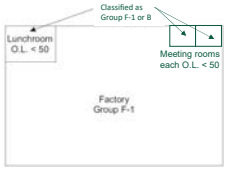


Retail Center with Individual Tenants

19

Occupancy Classification—Assembly Section 303.1.2, #1

Small assembly spaces: A room with an occupant load less than 50 and accessory to another occupancy is to be classified either as a part of that occupancy or as Group B.

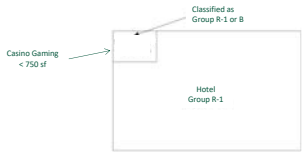


Example of small lunchrooms and meeting rooms in a manufacturing facility

20

Occupancy Classification—Assembly Section 303.1.2, #2

Small assembly spaces: Similar to Item #1, a room or space with a floor area of less than 750 square feet and accessory to another occupancy is to be classified as a part of that occupancy or as Group B.



Casino Gaming Area Associated with a Hotel

21

Occupancy Classification—Assembly

Spaces in Group A fall into two basic groups:

- Those assembly uses that occur within a building (Groups A-1, A-2, A-3 and A-4).
- Those assembly uses that occur in structures primarily open to the exterior (Group A-5).

22

Occupancy Classification—Assembly Section 303.2

Group A-1

Characteristics	Examples
▪ High occupant density	▪ Motion picture theaters
▪ Usually fixed seating	▪ Symphony/concert halls
▪ Foyers/lobbies	▪ Television/radio studios
▪ Stages, platforms or projection screen	▪ Performance theaters
▪ Low-light conditions	
▪ Sizable occupant loads	

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Occupancy Classification—Assembly Section 303.3

Group A-2

Characteristics	Examples
▪ Consumption of food and/or drink (primary characteristic)	▪ Banquet halls ▪ Night clubs
▪ Moderate occupant density ▪ Variable lighting levels ▪ Aisles not clearly defined ▪ Movable furnishings	▪ Restaurants ▪ Taverns and bars ▪ Casino gaming areas

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Occupancy Classification—Assembly Section 303.4

Group A-3

Characteristics	Examples
▪ Moderate occupant density	▪ Art galleries ▪ Exhibition halls
▪ Adequate lighting levels	▪ Libraries ▪ Museums
▪ Moderate fire loading	▪ Places of religious worship

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Assembly

- Group A-3 is the default classification for assembly occupancies.
- If an assembly use cannot obviously be classified as one of the four other indoor Group A classifications, then it should be considered as a Group A-3 occupancy.

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Assembly Section 303.5

Group A-4

Characteristics	Examples
▪ Lighting levels can fluctuate ▪ Some food or drink consumption ▪ Spectator seating typically fixed ▪ Medium to high density	▪ Arenas ▪ Skating rinks ▪ Gymnasiums

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Assembly Section 303.6

Group A-5

Characteristics	Examples
▪ No enclosure to contain smoke, although spectator might be protected from rain and sun	▪ Amusement park structures ▪ Bleachers and reviewing stands
▪ Limited or no conditioned air	▪ Grandstands
▪ Most seating is fixed	▪ Stadiums

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Business Section 304.1

Group B

Characteristics	Examples
▪ Many occupants are familiar with the premises ▪ Most occupants are adults capable of recognizing and effectively responding to "emergency situations" ▪ Moderate fire load	▪ Ambulatory care facilities ▪ Banks ▪ Barber/beauty shops ▪ Office areas ▪ Outpatient clinics ▪ Post offices ▪ Training and skill development

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Educational Sections 305.1, 305.2

Group E

Characteristics	Examples
▪ Six or more occupants at a time	▪ High schools (through 12th grade)
▪ Students younger than college age	▪ Middle schools ▪ Elementary schools
▪ 2½ years to the 12th grade is the general default age for this classification	▪ Preschools ▪ Day care facilities (more than 5 children, older than 2½ years)

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Educational Section 308.5.1

- **Classification as Group E:** A child care facility housing infants and toddlers is classified as Group E, rather that Group I-4, where:
  - More than 5, but no more than 100, children are 2½ years of age or less.
  - Rooms where such infants/toddlers are cared for are located on level of exit discharge.
  - Each of these infant/toddler care rooms has an exit door directly to the outside.

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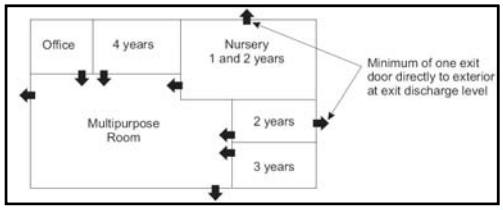
Occupancy Classification—Educational



Group E—Day Care Facility

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Occupancy Classification—Factory/Industrial Section 306.1

Group F occupancies are facilities where manufacturing operations and similar industrial activities occur, other than those classified as Group H. Operations may include assembling, fabricating, finishing, manufacturing, packaging, repair or processing work.

- F-1: where combustible materials are used in the operations.
- F-2: where all of the materials are noncombustible.

33

Occupancy Classification—Factory/Industrial Section 306.2

Group F-1 Moderate-Hazard Factory

Characteristics	Examples
▪ All Group F operations that are not considered Group F-2	▪ Aircraft, automobile, appliance and machine manufacturers ▪ Water/sewer treatment
▪ Production, assembling, finishing, packaging or repair of combustible products	▪ Clothing manufacturers ▪ Furniture makers ▪ Woodworking shops

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Occupancy Classification—Factory/Industrial Section 306.3

Group F-2 Low-Hazard Factory

Characteristics	Examples
▪ Similar to Group F-1, but no combustibles other than limited amounts in finishing, packing or processing operations	▪ Ceramic products ▪ Glass products ▪ Masonry manufacturing ▪ Metal fabrication plant

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Occupancy Classification—High Hazard Section 307.1

Group H occupancies:

- Involve the manufacturing, processing, generation or storage of materials that constitute a physical and/or health hazard.
- Quantities of such hazardous materials exceed those permitted within control areas as regulated by Section 414.2, based on Tables 307.1(1) and/or 307.1(2).

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Occupancy Classification—High Hazard Section 307.1.1

Conditions not considered as Group H: There are 19 conditions where a classification of Group H is not to be assigned, but rather the occupancy it most nearly resembles.

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Occupancy Classification—High Hazard Section 307.1.1

Conditions not considered as Group H include:

- Application of flammable finishes in conformance with Section 416 of the IFC and the IBC.
- Sales and storage of flammable and combustible liquids in Group M occupancies if compliant with the IFC.
- Refrigeration systems.
- Agricultural materials only stored or utilized on the premises.
- Distilling or brewing of beverages conforming to requirements of the IFC.

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Occupancy Classification

- Refer to Section 307.1 and Tables 307.1(1) and 307.1(2) to determine if buildings, structures or materials are exempt from the Group H classification.
- In accordance with Section 307.2, the design of high-hazard buildings must conform to additional requirements in the IFC and Section 414 of the IBC.

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Occupancy Classification—High Hazard Tables 307.1(1), 307.1(2)

- Use Table 307.1(1) for the maximum allowable quantities of materials posing a physical hazard.
- Use Table 307.1(2) for materials posing a health hazard.

If the quantity of hazardous materials does not exceed the calculated amount, then the use is not considered a Group H occupancy.

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TABLE 307.1(1)
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARD[a, b, m, n, o, p]

MATERIAL	CLASS	GROUP WHEN THE MAXIMUM ALLOWABLE QUANTITY IS EXCEEDED	STORAGE[c]			USE-CLOSED SYSTEMS[c]			USE-OPEN SYSTEMS[c]	
			Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)
Combustible dust	NA	H-2	See Note q	NA	NA	See Note q	NA	NA	See Note q	NA
Combustible fiber[q]	Loose Baled[p]	H-3	(100) (1,000)	NA	NA	(100) (1,000)	NA	NA	(20) (200)	NA
Combustible liquid[d, i]	II IIIA IIIB	H-2 or H-3 H-2 or H-3 NA	NA	120[e, i] 330[e, i] 13,200[e, i]	NA	NA	120[f] 330[f] 13,200[f]	NA	NA	30[f] 80[f] 3,300[f]
Cryogenic flammable	NA	H-2	NA	45[f]	NA	NA	45[f]	NA	NA	10[f]
Cryogenic inert	NA	NA	NA	NA	NL	NA	NA	NL	NA	NA
Cryogenic oxidizing	NA	H-3	NA	45[f]	NA	NA	45[f]	NA	NA	10[f]
Explosives	Division 1.1 Division 1.2 Division 1.3 Division 1.4 Division 1.4G Division 1.5 Division 1.6	H-1 H-1 H-1 or H-2 H-3 H-3 H-1 H-1	1[e, k] 1[e, k] 5[e, k] 50[e, k] 125[e, j] 1[e, k] 1[e, k]	(1)[e, k] (1)[e, k] (5)[e, k] (50)[e, k] NA (1)[e, k] NA	NA	0.25[e] 0.25[e] 1[e] 50[e] NA 0.25[e] NA	(0.25)[e] (0.25)[e] (1)[e] (50)[e] NA (0.25)[e] NA	NA	0.25[e] 0.25[e] 1[e] NA NA 0.25[e] NA	(0.25)[e] (0.25)[e] (1)[e] NA NA (0.25)[e] NA
Flammable gas	Gaseous Liquefied	H-2	NA	NA (150)[g, r]	1,000[g, r] NA	NA	NA (150)[g, r]	1,000[g, r] NA	NA	NA
Flammable liquid[d]	IA IB and IC	H-2 or H-3 H-2 or H-3	NA	30[g, r] 120[g, r]	NA	NA	30[g] 120[g]	NA	NA	10[g] 30[g]
Flammable liquid, combination (IA, IB, IC)	NA	H-2 or H-3	NA	120[g, r, s]	NA	NA	120[g, s]	NA	NA	30[g, s]

(continued)

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NL = Not Limited; NA = Not Applicable; UD = Unclassified Detonable.

a. For use of control areas, see Section 414.2.

b. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

c. The quantities of alcoholic beverages in retail and wholesale sales occupancies shall not be limited provided the liquids are packaged in individual containers not exceeding 1.3 gallons. In retail and wholesale sales occupancies, the quantities of medicines, foodstuffs or consumer products, and cosmetics containing not more than 50 percent by volume of water-miscible liquids with the remainder of the solutions not being flammable, shall not be limited, provided that such materials are packaged in individual containers not exceeding 1.3 gallons.

d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1. Where Note e also applies, the increase for both notes shall be applied accumulatively.

e. Maximum allowable quantities shall be increased 100 percent when stored in approved storage cabinets, day boxes, gas cabinets, gas rooms or exhausted enclosures or in listed safety cans in accordance with Section 5003.9.10 of the *International Fire Code*. Where Note d also applies, the increase for both notes shall be applied accumulatively.

f. Quantities shall not be limited in a building equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.

g. Allowed only in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.

h. Containing not more than the maximum allowable quantity per control area of Class IA, IB or IC flammable liquids.

i. The maximum allowable quantity shall not apply to fuel oil storage complying with Section 603.3.2 of the *International Fire Code*.

j. Quantities in parentheses indicate quantity units in parentheses at the head of each column.

k. A maximum quantity of 220 pounds of solid or 22 gallons of liquid Class 3 oxidizers is allowed when such materials are necessary for maintenance purposes, operation or sanitation of equipment when the storage containers and the manner of storage are approved.

l. Net weight of the pyrotechnic composition of the fireworks. Where the net weight of the pyrotechnic composition of the fireworks is not known, 25 percent of the gross weight of the fireworks, including packaging, shall be used.

m. For gallons of liquids, divide the amount in pounds by 10 in accordance with Section 5003.1.2 of the *International Fire Code*.

n. For storage and display quantities in Group M and storage quantities in Group S occupancies complying with Section 414.2.5, see Tables 414.2.5(1) and 414.2.5(2).

o. Densely packed baled cotton that complies with the packing requirements of ISO 8115 shall not be included in this material class.

p. The following shall not be included in determining the maximum allowable quantities:
1. Liquid or gaseous fuel in fuel tanks on vehicles.
2. Liquid or gaseous fuel in fuel tanks on motorized equipment operated in accordance with the *International Fire Code*.
3. Gaseous fuels in piping systems and fixed appliances regulated by the *International Fuel Gas Code*.
4. Liquid fuels in piping systems and fixed appliances regulated by the *International Mechanical Code*.
5. Alcohol-based hand rubs classified as Class I or II liquids in dispensers that are installed in accordance with Sections 5705.5 and 5705.5.1 of the *International Fire Code*. The location of the alcohol-based hand rub (ABHR) dispensers shall be provided in the construction documents.

q. Where manufactured, generated or used in such a manner that the concentration and conditions create a fire or explosion hazard based on information prepared in accordance with Section 414.1.3.

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[F] TABLE 307.1(2)
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIAL POSING A HEALTH HAZARD[a, c, e, g, h, i]

MATERIAL	STORAGE[d]			USE-CLOSED SYSTEMS[d]			USE-OPEN SYSTEMS[d]	
	Solid pounds[b, e]	Liquid gallons (pounds)[b, e]	Gas cubic feet at NTP (pounds)[f]	Solid pounds[b]	Liquid gallons (pounds)[f]	Gas cubic feet at NTP (pounds)[f]	Solid pounds[b]	Liquid gallons (pounds)[f]
Corrosives	5,000	500	Gaseous 810[f] Liquefied (150)	5,000	500	Gaseous 810[f] Liquefied (150)	1,000	100
Highly Toxic	10	(10)	Gaseous 20[f] Liquefied (4)[g]	10	(10)	Gaseous 20[f] Liquefied (4)[g]	3	(3)
Toxic	500	(500)	Gaseous 810[f] Liquefied (150)[f]	500	(500)	Gaseous 810[f] Liquefied (150)[f]	125	(125)

For SI: 1 cubic foot = 0.028 m³, 1 pound = 0.454 kg, 1 gallon = 3.785 L.

a. For use of control areas, see Section 414.2.

b. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

c. In retail and wholesale sales occupancies, the quantities of medicines, foodstuffs or consumer products, and cosmetics containing not more than 50 percent by volume of water-miscible liquids and with the remainder of the solutions not being flammable, shall not be limited, provided that such materials are packaged in individual containers not exceeding 1.3 gallons.

d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an *approved automatic sprinkler system* in accordance with Section 903.3.1.1. Where Note e also applies, the increase for both notes shall be applied accumulatively.

e. Maximum allowable quantities shall be increased 100 percent where stored in approved storage cabinets, gas cabinets or exhausted enclosures as specified in the *International Fire Code*. Where Note d also applies, the increase for both notes shall be applied accumulatively.

f. For storage and display quantities in Group M and storage quantities in Group S occupancies complying with Section 414.2.5, see Tables 414.2.5(1) and 414.2.5(2).

g. Allowed only where stored in approved exhausted gas cabinets or exhausted enclosures as specified in the *International Fire Code*.

h. Quantities in parenthesis indicate quantity units in parenthesis at the head of each column.

i. For gallons of liquids, divide the amount in pounds by 10 in accordance with Section 5003.1.2 of the *International Fire Code*.

43

Occupancy Classification—High Hazard Section 414.2

Control Areas

If the amount of hazardous materials exceeds that provided by Table 307.1(1) or 307.1(2), it is still possible that a Group H occupancy does not exist.

Additional quantities are permitted in non-Group H buildings if they are properly distributed in control areas complying with Section 414.2.

44

Occupancy Classification—Laboratory Suites Section 428

A similar approach to the regulation of hazardous materials is established in Section 428 regarding laboratory suites.

TABLE [F] 428.3
DESIGN AND NUMBER OF LABORATORY SUITES PER FLOOR

FLOOR LEVEL		PERCENTAGE OF THE MAXIMUM ALLOWABLE QUANTITY PER LAB SUITE[a]	NUMBER OF LAB SUITES PER FLOOR	FIRE-RESISTANCE RATING FOR FIRE BARRIERS IN HOURS[b]
Above Grade Plane	21+	Not allowed	Not Permitted	Not Permitted
	16-20	25	1	2
	11-15	50	1	2
	7-10	50	2	2
	4-6	75	4	1
	3	100	4	1
	1-2	100	6	1
Below Grade Plane	1	75	4	1
	2	50	2	1
	Lower than 2	Not Allowed	Not Allowed	Not Allowed

a. Percentages shall be of the maximum allowable quantity per control area shown in Tables 307.1(1) and 307.1(2), with all increases allowed in the footnotes to those tables.

b. Fire barriers shall include walls, floors and ceilings necessary to provide separation from other portions of the building.

c. Vertical fire barriers separating laboratory suites from other spaces on the same floor shall be permitted to be 1-hour fire-resistance rated.

45

Occupancy Classification—High Hazard

Where the amount of hazardous materials exceeds those permitted in complying control areas or laboratory suites, and is such that none of the conditions set forth in Section 307.1.1 are applicable, then the use is classified as a Group H occupancy.

There are 5 categories of Group H to address the hazards more directly.

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Occupancy Classification—High Hazard

Types of Materials by Group
Group H-1 (Section 307.3)

- Explosives
- Detonable pyrophoric materials
- Organic peroxides, unclassified detonable
- Oxidizers, Class 4
- Unstable (reactive) materials, Class 3 detonable and Class 4

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Occupancy Classification—High Hazard

Types of Materials by Group
Group H-2 (Section 307.4)

- Combustible dust
- Flammable and combustible liquids (Class I, II and IIIA) in open systems
- Cryogenic fluids, flammable
- Organic peroxides, Class I
- Flammable gases
- Oxidizers, Class 3, in open systems
- Pyrophoric materials, nondetonable
- Unstable (reactive) materials, Class 3, nondetonable
- Water-reactive materials, Class 3

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Occupancy Classification—High Hazard

Types of Materials by Group

Group H-3 (Section 307.5)

- Combustible fibers
- Flammable and combustible liquids (Class I, II and IIIA) in closed systems
- Flammable solids
- Organic peroxides, Classes II and III
- Oxidizers, Class 2
- Oxidizers, Class 3, in closed systems
- Oxidizing gases
- Unstable (reactive) materials, Class 2
- Water-reactive materials, Class 2
- Cryogenic fluids, oxidizing
- Consumer fireworks, 1.4G (Class C, Common)

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—High Hazard

Types of Materials by Group

Group H-4 (Section 307.6)

- Corrosives
- Toxic materials
- Highly toxic materials

Group H-5 (Section 307.7)

- Semiconductor fabrication facilities and comparable research and development areas

2021 IBC Occupancy Classification and Mixed Occupancies

50

Occupancy Classification—Institutional

- Group I—Characteristics
  - People are cared for or live in a supervised environment.
  - People with physical limitations because of health or age are harbored for medical treatment or other care/treatment.
  - People who are detained for penal or correctional purposes or in which the liberty of the occupants is restricted.

2021 IBC Occupancy Classification and Mixed Occupancies

51

Occupancy Classification—Institutional

Group I-1 (Section 308.2)

Characteristics

- More than 16 occupants (not including staff).
- Residents—require assistance with day-to-day living tasks.
- Housed on a 24-hour basis.
- Custodial care includes persons who evacuate at a slower rate.
- Residents may have mental and psychiatric complications.

Examples

- Group homes
- Rehabilitation facilities
- Halfway houses
- Assisted living facilities

2021 IBC Occupancy Classification and Mixed Occupancies

52

Occupancy Classification—Institutional

Group I-1 (Section 308.2)

- Group I-1, Condition 1
  - All persons receiving custodial care are capable, without assistance, of responding to an emergency situation to complete building evacuation or relocation.
- Group I-1, Condition 2
  - Any persons receiving custodial care who require limited verbal or physical assistance while responding to an emergency situation to complete building evacuation or relocation.

2021 IBC Occupancy Classification and Mixed Occupancies

53

Occupancy Classification—Institutional

Group I-2 (Section 308.3)

Characteristics

- Used for medical care activities for six or more persons.
- Receive 24-hour care.
- May be semi-aware or semi-ambulatory, but not capable of self-preservation.

Examples

- Hospitals
- Detoxification facilities
- Nursing homes
- 24-hour infant/toddler care facilities (foster care facilities)

2021 IBC Occupancy Classification and Mixed Occupancies

54

Occupancy Classification—Institutional

Group I-2 (Section 308.3)

- Group I-2, Condition 1
  - Nursing homes, foster care facilities and similar uses that provide nursing and medical care but do not provide emergency care, surgery and obstetrics.
- Group I-2, Condition 2
  - Hospitals and similar facilities that provide nursing and medical care, and could also provide emergency care, surgery and obstetrics.

55

Occupancy Classification—Institutional

Group I-3 (Section 308.4)

Characteristics

- More than 5 occupants (not including staff).
- Supervised.
- Physically restricted from evacuating the building.
- Further classified into 5 occupancy conditions based on capability of free movement within facility.

Examples

- Detention centers
- Jails
- Prerelease centers
- Prisons

56

Occupancy Classification—Institutional

Group I-4 (Section 308.5)

Characteristics

- More than 5 occupants.
- Any age.
- Receive custodial care for less than 24 hours a day.
- Occupants incapable of self preservation.

Examples

- Adult care facilities
- Child care facilities

57

Occupancy Classification—Institutional

Group I-4 (Section 308.5.1)

- **NOTE:** Child day care facilities are classified as Group E if all of the following apply:
  - More than 5 but not more than 100 children, 2½ years of age or less.
  - Rooms where such children are located are on the level of exit discharge.
  - Each such room has an exit door directly to the outside.

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Occupancy Classification—Mercantile

Group M (Section 309.1)

Characteristics

- Display, sell and stock merchandise.
- If merchandise is hazardous, see Table 414.2.5(1) for quantity limits.

Examples

- Retail stores
- Motor fuel-dispensing facilities

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Occupancy Classification—Residential

- Residential occupancies fall into two categories:
  - Transient (Group R-1)
  - Nontransient (Group R-2)
  - Transient/Nontransient (Groups R-3 and R-4)

Transient—Occupancy of a dwelling unit or sleeping unit for not more than 30 days.

- In addition, residential occupancies are regulated as dwelling units and sleeping units

60

Occupancy Classification—Residential

Group R-1 (Section 310.2)

Characteristics

- Occupants are primarily transient.
- Includes sleeping units and/or dwelling units.

Examples

- Hotels
- Motels
- Boarding houses (transient)*
- Bed and breakfast establishments*

* Congregate living facilities for transient occupants are classified as Group R-3 occupancies where the occupant load is 10 or less.

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Residential

Group R-2 (Section 310.3)

Characteristics

- Occupants are primarily permanent.
- Consists of congregate living facilities or apartment buildings (3 or more dwelling units).

Examples

- Apartment houses
- Dormitories*
- Fraternities and sororities*
- Monasteries and convents*

* Congregate living facilities (nontransient) with 16 or fewer occupants are classified as Group R-3 occupancies.

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Residential

Group R-3 (Section 310.4)

Characteristics

- Occupants not transient in nature.
- Typically small occupant loads.

Examples

- One- and two-family dwellings outside the scope of the IRC.*
- Smaller congregate living facilities.
- Adult care and child care facilities for 5 or fewer persons for less than 24 hours.

- Detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories in height with separate means of egress are typically regulated by the IRC, so the IBC is not applicable.

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Residential Section 310.4

- Group R-3 occupancies also include:
  - Care facilities providing accomodations for 5 or fewer persons receiving care,
  - Congregate living facilities (transient) with10 or fewer occupants,
  - Congregate living facilities (nontransient) with 16 or fewer occupants,
  - Lodging houses (such as bed-and-breakfasts) with 5 or fewer guest rooms and 10 or fewer occupants,
    - Owner-occupied lodging houses with 5 or fewer guest rooms and 10 or fewer total occupants permitted to be constructed per the IRC.

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Residential

Group R-4 (Section 310.5)

Characteristics

- Care facilities having more than 5 but not more than 16 occupants, excluding staff.

Examples

- Residential care facilities
- Assisted living facilities

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Residential

Group R-4 (Section 310.5)

- Group R-4, Condition 1
  - All persons receiving custodial care are capable, without assistance, of responding to an emergency situation to complete building evacuation or relocation.
- Group R-4, Condition 2
  - Any persons receiving custodial care who require limited verbal or physical assistance while responding to an emergency situation to complete building evacuation or relocation.

2021 IBC Occupancy Classification and Mixed Occupancies

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Occupancy Classification—Residential Section 310.5

- Group R-4 occupancies shall meet the requirements for construction as defined for Group R-3, except as otherwise provided.

67

Occupancy Classification—Storage

- Group S classifications are similar to those in the Group F categories.
- Those storage occupancies classified as Group S-1 typically contain some degree of combustible materials.
- No storage of combustible materials is anticipated in Group S-2 occupancies.

68

Occupancy Classification—Storage

Group S-1, Moderate Hazard (Section 311.2)

Characteristics

- Storage of primarily combustible materials that do not qualify as hazardous materials beyond the exempt amount permitted (see Section 307).

Examples

- Clothing, woolen wearing apparel, silks
- Furniture storage
- Motor vehicle repair garages
- Paper products
- Tires, bulk storage

69

Occupancy Classification—Storage

Group S-2, Low Hazard (Section 311.3)

Characteristics

- Storage of noncombustibles, with a minimal amount of combustibles present such as plastic knobs, wood pallets, and some paper or cardboard boxing.

Examples

- Food product storage
- Glass storage
- Metal storage
- Parking garages
- Pottery storage

70

Occupancy Classification—Utility and Miscellaneous

Group U (Section 312.1)

Characteristics

- No public occupancy
- Limited or no occupant load
- Limited floor area
- Little fire hazard

Examples

- Agricultural buildings
- Barns
- Carports
- Tanks and towers
- Livestock shelters
- Private garages
- Stables

71

Occupancy Classification—Summary

- Once the occupancy classification(s) determination is complete, it is now possible to begin application of the remainder of the code.

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ICC SPRING INTERCHANGE

Mixed Occupancies

73

Concept of Mixed Occupancies

Module 1

IBC 2021

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Definition

- A mixed-occupancy condition occurs where two or more distinct occupancy classifications are determined to exist in the same building.
- Under such circumstances, the designer has available several different methodologies in Section 508 to address the mixed-occupancy building.
- Compliance with at least one of the methods is mandatory.

75

General Provisions Section 508.1

- Three options established in Section 508 to address mixed-occupancy buildings include:
  - Accessory Occupancies.
  - Nonseparated Occupancies.
  - Separated Occupancies.
- Methods for determining maximum allowable size, height and area and separations are identified for each option.
- One of the three options must be applied to a mixed-occupancy condition.

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Application of the Mixed Occupancy Methods

Module 5

IBC 2021

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Mixed Occupancies: Overview Section 508.1

- There are five key components that regulate mixed-occupancy buildings:
  - Occupancy classification.
  - Fire protection systems.
  - Allowable height.
  - Allowable area.
  - Fire-resistive separation.
- The three mixed-occupancy options differ from each other based on one or more of these five components.

78

Application of Three Options Section 508.1

- Section 508.1 mandates that one of the three options must be applied where a mixed occupancy exists.
  - Determination of the option depends on owner/designer decisions.
    - Building function.
    - Construction costs.
    - Design flexibility.
  - Compliance with at least one of the three options to be verified by building official.

79

Use of Multiple Options Section 508.1

- Owner/designer may choose to use more than one option within same building.
- Nonseparated occupancies: aggregate area of nonseparated occupancies evaluated as single hazard
- Separated occupancies option: relationship between multiple pairs of adjacent occupancies to be individually analyzed
- Accessory occupancies option: limit on accessory occupancies viewed on a story-by-story basis

80

Conditions Where Not Applicable Section 508.1, Exceptions

- There are two conditions under which the provisions of Section 508 do not apply:
  - Occupancies regulated under the special provisions height and area provisions of Section 510.
  - Group H-1, H-2 and H-3 occupancies where required to be in a detached building by Table 415.6.5.

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Nonseparated Occupancies

Module 6

82

Nonseparated Occupancies Overview

- "Nonseparated occupancies" method considers most restrictive requirements for fire protection and allowable height/area for occupancies involved
- This method beneficial to designer due to:
  - No requirement to separate occupancies
  - Flexibility allowed by application of "worst-case" approach to fire protection and building size.
- No requirements for a fire-resistance-rated separation between adjacent occupancies.
- Nonseparated occupancies method is most common of methods utilized.

83

Nonseparated Occupancies: Classifications Section 508.3.1

- Occupancy classification based on the general provisions of Section 302.1.
- Individually classified based on the occupancy of each individual space.

84

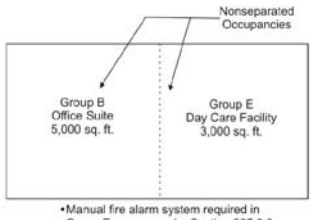
Nonseparated Occupancies: Fire Protection Section 508.3.1

- Most restrictive applicable provisions of Chapter 9 regulating fire-protection systems apply to the total nonseparated occupancy area, not just the specific individual occupancy, and typically address:
  - Automatic sprinkler systems.
  - Fire alarm systems.

85

Nonseparated Occupancies: Fire Protection Section 508.3.1

Example



- Manual fire alarm system required in Group E occupancy by Section 907.2.3 required throughout entire building.

86

Nonseparated Occupancies: Allowable Area and Height – Section 508.3.2

- The maximum allowable height and area of building is based on the most restrictive allowances for the occupancy groups under consideration.
- The most restrictive allowable area is applied to the entire building.
- Same limitation is applied to the building's height.

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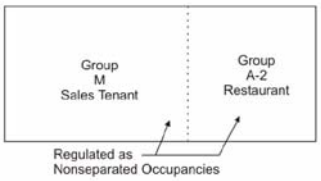
Nonseparated Occupancies: Allowable Area and Height – Section 508.3.2

Example: Building is to be multistory, fully sprinklered and of Type VB construction. Frontage increase of 30 percent available.
1st story contains Group M and A-2 occupancies as shown with Group B occupancy above.



For SI: 1 square foot = 0.0929 m².

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Nonseparated Occupancies: Allowable Area and Height – Section 508.3.2

	Group M	Group A-2	Group B
Allowable Area (square feet)	29,700	19,800	29,700
Allowable Height (number of stories)	2	2	3

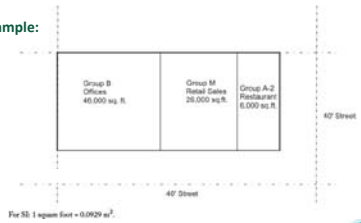
Result: **Building is limited to 2 stories and 19,800 sf per story to comply with Nonseparated Occupancies method**

89

Nonseparated Occupancies Example: Allowable Area - Section 508.3.2

- **Given:** A one-story, 78,000-square-foot, fully sprinklered building with three occupancy groups as shown. The building is of Type IIB construction and adjoins two public ways that qualify for a 50-percent frontage increase.
- **Determine:** Does the building comply with the area limitations based on nonseparated occupancies?

Example:



For SI: 1 square foot = 0.0929 m².

90

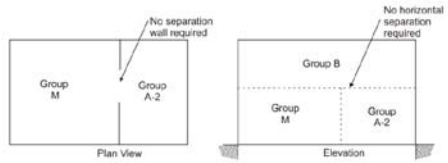
Nonseparated Occupancies Example: Allowable Area - Section 508.3.2

- Allowable building area to be based on the most restrictive allowances for the occupancy groups under consideration based on the building's type of construction:
  - **Group A-2: 38,000 + 4,750 = 42,750 sf**
  - Group B: 92,000 + 11,500 = 103,500 sf
  - Group M: 50,000 + 6,250 = 56,250 sf
- Therefore, the building does not comply for "nonseparated occupancies" because actual area (78,000 sf) exceeds most restrictive allowable area (42,750 sf).

91

Nonseparated Occupancies: Separations Section 508.3.3

- Application of this option will result in no physical or fire-resistance-rated separation between the nonseparated occupancies.



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Nonseparated Occupancies Section 508.3.3, Exceptions

- Group H-2, H-3, H-4 and H-5 occupancies must be separated from all other occupancies per Section 508.4 (separated occupancies).
- Group I-1, R-1, R-2 and R-3 dwelling units and sleeping units must be separated from each other and from all other occupancies contiguous to them per Section 420.

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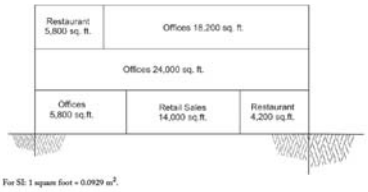
Nonseparated Occupancies: A Four-Step Process

1. Determine the occupancies present in the building.
2. Apply the most restrictive fire protection requirements of Chapter 9 to the entire building.
3. Determine the maximum allowable height and area for each occupancy. Apply the most restrictive to the entire building.
4. Apply all other code requirements to each portion of the building based on the occupancy classification of that portion.

94

Nonseparated Occupancies: Applying the Process

- **Given:** A three-story, Type IIB building containing assembly, business and mercantile uses. The building is fully sprinklered and does not qualify for any frontage increase for allowable area purposes. Each story is 24,000 square feet in floor area.
- **Determine:** Does the building comply with the nonseparated mixed occupancy option?



95

Nonseparated Occupancies: Applying the Process

- **Solution:**
  1. Determine the occupancies in the building.
     - Group A-2
     - Group B
     - Group M
  2. Apply the most restrictive fire protection requirements of Chapter 9 to the entire building.
     - Building to be fully sprinkered due to Group A-2 occupancy located above the level of exit discharge.
     - Building to be provided throughout with manual fire alarm system due to more than 100 persons in Group B above the level of exit discharge.

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Nonseparated Occupancies: Applying the Process

3. Determine the maximum allowable height and area for each occupancy. Apply the most restrictive to the entire building.

	Group A-2	Group B	Group M
Allowable Height (number of stories)	3	4	3
Allowable Area per Story (square feet)	28,500	69,000	37,500
Allowable Building Area (square feet)	85,500	207,000	112,500

Building limited to:
- 3 stories
- 28,500 sf per story
- 85,500 sf per building

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Nonseparated Occupancies: Applying the Process

4. Apply all other code requirements to each portion of the building based on the occupancy classification of that portion.
   Apply all other provisions based on the specific occupancy as applicable.

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Separated Occupancies

Module 7

99

Separated Occupancies Overview

- "Separated occupancies" method uses a balanced approach to regulating mixed occupancy conditions.
- This method is typically applied where nonseparated occupancies method is impractical, undesirable or unavailable.
- Separated occupancies method to be applied where Group H-2, H-3, H-4 and H-5 occupancies are present.
  - Group H-1 to be located in detached (single-occupancy) buildings not used for other purposes.

100

Separated Occupancies Section 508.4

- Separated occupancies is the only one of the three options where a fire-resistance-rated occupancy separation is required under mixed-occupancy conditions.
- Table 508.4 is referenced to determine the degree of fire resistance that is mandated for separations.
- Separations may not be required where occupancies are considered to be of same level of hazard.

101

Separated Occupancies Section 508.4.1

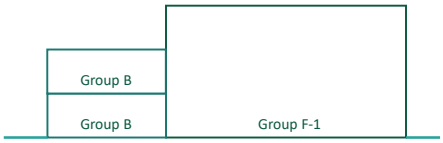
- This approach also differs from the other options regarding fire protection requirements:
  - The fire protection requirements of Chapter 9 are to be applied individually in each portion of the building based on the occupancies in each portion, however:
  - Where nonfire-barrier-separated occupancies are permitted by Table 508.4, the most restrictive provisions of Chapter 9 that apply to the separated occupancies shall apply to the total nonfire-barrier-separated occupancy areas.

102

Separated Occupancies Example Section 508.4.1

EXAMPLE:

If 2nd story of Group B occupancy has an occupant load > 100, a manual fire alarm system is required in the Group B portion of the building by Section 907.2.2, #2.



Under separated occupancies, the fire alarm system shall be:
- Extended to the Group F-1 portion of the building, OR
- A fire area separation by a minimum 3-hour fire barrier shall be provided between the Group B and the Group F-1

103

Separated Occupancies Sections 508.4.2, 508.4.3

- In addition, this approach differs from the other options regarding allowable height and area:
  - The allowable height for each occupancy within the building is based on Section 503.1, consistent with the method for single-occupancy buildings.
  - The allowable area of the building is based on the sum of the ratios where the actual floor area of each occupancy divided by the allowable floor area of each occupancy is not to exceed 1.0 (unity formula).

$$a_1/A_1 + a_2/A_2 + a_3/A_3 + \ldots \leq 1.0$$

104

Separated Occupancies: Occupancy Classifications – Section 508.4.1

- This option requires that the occupancies be classified individually based on their specific functions.
- Requirements for means of egress, automatic sprinkler systems, fire alarm systems, plumbing facilities and all other provisions are to be applied individually to the various occupancies in the building.

105

Separated Occupancies: Allowable Area Section 508.4.2

- When a mixed-occupancy building is regulated under the provisions of Section 508.4 for separated occupancies, the unity formula is used in the determination of allowable area.
- Compliance for allowable area can only be achieved where the sum of the ratios of actual floor area divided by allowable floor areas for each of the occupancies involved does not exceed 1.

106

Separated Occupancies: Allowable Area Section 508.4.2

- The formula can be expressed as:

$$a_1/A_1 + a_2/A_2 + a_3/A_3 + \ldots \leq 1.0$$

  - a_1, a_2 and a_3 represent the actual floor areas for the individual occupancies.
  - A_1, A_2 and A_3 represent the maximum allowable areas for the same respective occupancies.
- Calculation applied regardless of any required separation.
- Applicable frontage increase for entire building applied to each of the occupancies.
- Sprinkler increase applied on a "per occupancy" basis.

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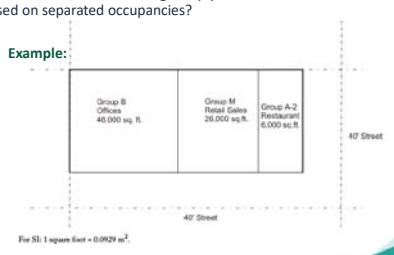
Separated Occupancies: Allowable Area Section 508.4.2

- **Given:** A one-story, 78,000-square-foot, fully sprinklered building with three occupancy groups as shown. The building is of Type IIB construction and adjoins two public ways that qualify for a 50-percent frontage increase.
- **Determine:** Does the building comply with the allowable area limitations based on separated occupancies?

Example:



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Separated Occupancies: Allowable Area Section 508.4.2

Solution: Apply the unity formula of Section 508.4.2 to determine compliance with allowable area.

Occupancy	Actual Area	Tabular Area Table 506.2	Allowable Area w/ Frontage Increase
Group A-2	6,000	38,000	42,750
Group B	46,000	92,000	103,500
Group M	26,000	50,000	56,250

$$\frac{a_a}{A_a} + \frac{a_M}{A_M} + \frac{a_{A-2}}{A_{A-2}} \leq 1.0\ ?$$

6,000/42,750 + 46,000/103,500 + 26,000/56,250 ≤ 1.0 ???

0.14 + 0.44 + 0.46 ≤ 1.0 ???

1.04 is not ≤ 1.0, therefore allowable area is exceeded.

What options are available to the designer to bring the building into compliance?

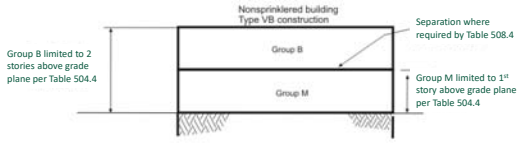
109

Separated Occupancies: Allowable Height Section 508.4.3

- Each individual occupancy in a multiple-story, mixed-occupancy building is regulated for height independently based on Section 503.1.
- Maximum number of stories for each occupancy is limited by the type of construction in Section 503.1.
  - Maximum height in feet is typically unaffected as it is most commonly based on construction type and sprinkler protection.
    - Does not vary based on occupancy classification
    - Where allowable height in feet varies among occupancies, each occupancy is also individually limited.

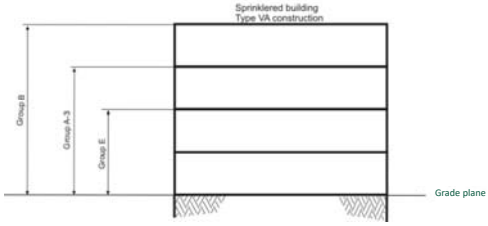
110

Separated Occupancies: Allowable Height Section 508.4.3



111

Separated Occupancies: Allowable Height Section 508.4.3



112

Separated Occupancies: Separations Section 508.4.4

- The requirements for a fire-resistance-rated separation between adjacent occupancies vary.
- The requirements are established in Table 508.4.
- Fire barriers and horizontal assemblies are to be utilized in the complete separation of adjacent occupancies with different levels of hazard.
- Table 508.4 allows for some occupancy pairs to be adjacent with no required fire-resistive or physical separation.

113

Separated Occupancies: Separations – Section 508.4.4

REFER TO CODE BOOK

2021 IBC Table 508.4 Page 5-13

TABLE 508.4
REQUIRED SEPARATION OF OCCUPANCIES (HOURS)[a]

OCCUPANCY	A, E		I-1[e], I-3, I-4		I-2		R[e]		F-2, S-2[g], U		B[g], F-1, M, S-1		H-1		H-2		H-3, H-4		H-5	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2	NP	NP	3	4	2	3	2	NP
I-1[e], I-3, I-4	1	2	N	N	2	NP	1	NP	1	2	1	2	NP	NP	3	NP	2	NP	2	NP
I-2	2	NP	2	NP	N	N	2	NP	2	NP	2	NP	NP	NP	3	NP	2	NP	2	NP
R[e]	1	2	1	NP	2	NP	N	N	1[c]	2[c]	1	2	NP	NP	3	NP	2	NP	2	NP
F-2, S-2[g], U	N	1	1	2	2	NP	1[c]	2[c]	N	N	1	2	NP	NP	3	4	2	3	2	NP
B[g], F-1, M, S-1	1	2	1	2	2	NP	1	2	1	2	N	N	NP	NP	2	3	1	2	1	NP
H-1	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	N	NP	NP	NP	NP	NP	NP	NP
H-2	3	4	3	NP	3	NP	3	NP	3	4	2	3	NP	NP	N	NP	1	NP	1	NP
H-3, H-4	2	3	2	NP	2	NP	2	NP	2	3	1	2	NP	NP	1	NP	1[d]	NP	1	NP
H-5	2	NP	2	NP	2	NP	2	NP	2	NP	1	NP	NP	NP	1	NP	1	NP	N	NP

S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
NS = Buildings not equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
N = No separation requirement.
NP = Not Permitted.

114

Separated Occupancies: A Five-Step Process

1. Determine the various occupancies that occur within the building.
2. Determine the minimum required fire-resistance rating between adjacent occupancies.
3. Verify that the building does not exceed the maximum allowable area for the type of construction involved.
4. Verify that the locations of the occupancies do not exceed their maximum allowable height based on the building's type of construction.
5. Apply all other code requirements to each portion of the building based on the occupancy of that portion.

115

Mixed Occupancies Practice

- **Given:** A one-story, multiple-tenant retail center containing Group A-2, A-3, B and M occupancies as shown. The 52,000-square-foot building is fully sprinklered, of Type IIB construction and has adequate frontage for a 50-percent allowable area increase.
- **Determine:** Does this building comply with Section 508.4 for separated occupancies?

Type IIB construction
Fully sprinklered, Retail Center

Group A-2 6,000 square feet	Group B 10,000 square feet	Group M 10,000 square feet	Group B 10,000 square feet	Group A-3 10,000 square feet
Group A-2 6,000 square feet				

For SI: 1 square foot = 0.0929 m².

116

Mixed Occupancies Practice

- **Determine:** Does this building comply with Section 508.4 for separated occupancies?

Type IIB construction
Fully sprinklered, Retail Center

Group A-2 6,000 square feet	Group B 10,000 square feet	Group M 10,000 square feet	Group B 10,000 square feet	Group A-3 10,000 square feet
Group A-2 6,000 square feet				

For SI: 1 square foot = 0.0929 m².

One-hour fire barriers provide separation between all tenant spaces

117

Mixed Occupancies Practice Solution

Minimum Occupancy Separation	Since building is fully sprinklered: A-2 /A-2 none required A-2 /M: 1-hour M/M: none required M/B: none required B/A-3 1-hour All OK
Allowable Height	Building is single story. OK
Allowable Area	A-2: 38,000 + 4,750 = 42,750 sf A-3: 38,000 + 4,750 = 42,750 sf B: 92,000 + 11,500 = 103,500 sf M: 50,000 + 6,250 = 56,250 sf 12,000/42,750 + 10,000/42,750 + 10,000/103,500 + 20,000/56,250 ≤ 1 0.28 + 0.23 + 0.10 + 0.36 = 0.97 OK

118

Accessory Occupancies

Module 8

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Accessory Occupancies Overview

- "Accessory occupancies" method is only applicable where support occupancies are relatively small compared to major occupancy.
- This method beneficial to designer due to:
  - No requirement to separate accessory occupancies from major occupancy.
  - In determination of allowable building area, area based on accessory occupancy as part of major occupancy.
- Accessory occupancies method has limited application.

120

Accessory Occupancies Section 508.2

- Must be subsidiary to the main occupancy of the building or to a portion of the building.
  - Examples of occupancies that may be considered as subsidiary to the main occupancy:
    - Group A-2 employee lunchroom within a Group S-1 warehouse.
    - Group A-3 training room in a Group B office building.
    - Group M showroom within a Group F-1 manufacturing building.
    - Group R-3 manager's dwelling unit within a Group S-1 self-storage facility.

121

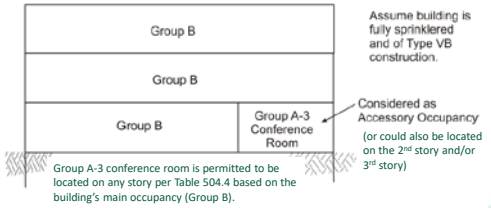
Accessory Occupancies: Occupancy Classification – Section 508.2.1

- Must be assigned to an occupancy group established in Chapter 3 based on unique characteristics.
- The spaces of the building considered as accessory occupancies must meet all code requirements applicable to the specific to the accessory occupancy classification, not that of the main occupancy, including:
  - Means of egress requirements.
  - Fire protection requirements.

122

Accessory Occupancies: Allowable Building Height - Section 508.2.2

- Allowable number of stories limited to that set forth in Section 504 for the main occupancy.



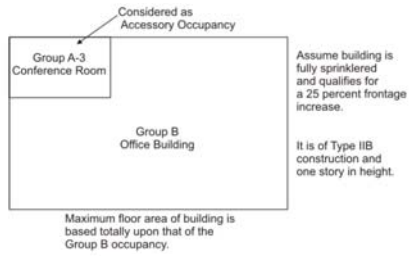
123

Accessory Occupancies: Allowable Building Area Section 508.2.3

- Allowable area of building is based on the main occupancy.
- Combined area of the main occupancy and accessory occupancy cannot exceed that permitted by Section 503.1 for the main occupancy.

124

Accessory Occupancies: Allowable Building Area Section 508.2.3



92,000 Table 506.2
5,750 Frontage increase
97,750 Total allowable area in square feet

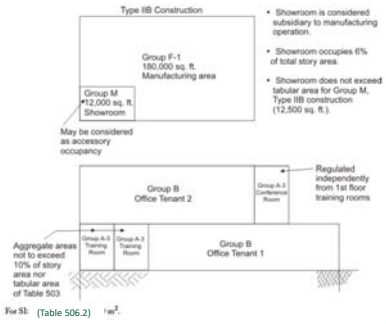
125

Accessory Occupancies: Allowable Building Area Section 508.2.3

- Limited to 10 percent of the floor area of the story located.
  - When more than one accessory occupancy is under consideration, the aggregate area of such occupancies are used to determine compliance.
- Floor area cannot exceed the tabular values for nonsprinklered buildings established by Table 506.2 for each accessory occupancy.

126

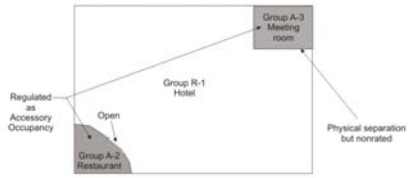
Accessory Occupancies Examples



127

Accessory Occupancies: Separation Section 508.2.4

- Application of the accessory occupancy option will result in no physical or fire-resistance-rated separation being mandated.



128

Accessory Occupancies: Section 508.2.4, Exceptions

- Group H-2, H-3, H-4 and H-5 occupancies to be separated from all other occupancies per Section 508.4 (separated occupancies).
- Group I-1, R-1, R-2 and R-3 dwelling units and sleeping units to be separated from each other and from accessory occupancies contiguous to them per Section 420.

129

Accessory Occupancies: A Seven-Step Process

1. Determine the various occupancy classifications that are found within the building.
2. Verify that any occupancy group under consideration as an accessory occupancy is subsidiary to the major occupancy of the building.
3. Verify that the floor area of the accessory occupancy does not exceed 10 percent of the floor area of the story in which it is located.
4. Verify that the floor area of the accessory occupancy does not exceed the tabular values for nonsprinklered buildings set forth in Table 506.2 for the building's type of construction.

130

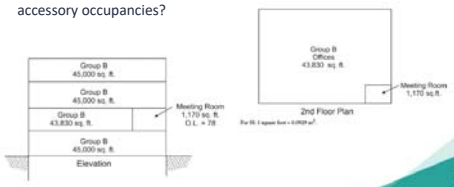
Accessory Occupancies: A Seven-Step Process

5. Limit the building's floor area to the allowable floor area based on the allowable area for the main occupancy.
6. Limit the maximum allowable height of the accessory occupancy based on Section 504 for the main occupancy.
7. Apply all other code requirements to each portion of the building based on the individual occupancy classification of the space.

131

Accessory Occupancies: Applying the Process

- **Given:** A four-story office building with a large meeting room (occupant load of 78) on the second floor. The building is fully sprinklered; is Type IIB construction and qualifies for a 75 percent frontage increase for allowable area. Each story of the building contains 45,000 square feet and the floor area of the meeting room is 1,170 square feet. It is intended that no fire-resistant occupancy separation be provided between the meeting room and the remainder of the building.
- **Determine:** Do the mixed-occupancy conditions comply with the requirements for accessory occupancies?



132

Accessory Occupancies: Applying the Process

- **Solution:**
  - Determine the various occupancy classifications that are found within the building.
    - Offices: Group B
    - Meeting Room: Group A-3
  - Verify that any occupancy group under consideration as an accessory occupancy is subsidiary to the occupancy of the building.
    - The meeting room use is directly related to the function of the office environment.

133

Accessory Occupancies: Applying the Process

- Verify that the floor area of the accessory occupancy does not exceed 10 percent of the floor area of the story in which it is located.
  - Floor area of meeting room is 1,170 square feet, approximately 3 percent of the floor area of the 2nd story.
- Verify that the floor area of the accessory occupancy does not exceed the tabular floor area (without area increases of Section 506) set forth in Table 503 for the building's type of construction.
  - Floor area of 1,170 square feet does not exceed tabular area of 9,500 square feet for Group A-3 in Type IIB construction.

134

Accessory Occupancies: Applying the Process

- Limit the building's floor area to the allowable floor area based on the allowable area for the main occupancy.

Tabular area	**69,000 sf**	**Based on all Group B**
Frontage increase	**17,250 sf**	**75% increase**
Total per story	**86,250 sf**	
Total for building	**258,000 sf**	**3x allowable/story**

135

Accessory Occupancies: Applying the Process

- Limit the maximum allowable height of the accessory occupancy based on Section 504.
  - Group A-2 occupancy limited to 1st, 2nd and/or 3rd stories.
- Apply all other code requirements to each portion of the building based on the individual occupancy classification of the space.
  - Means of egress, fire protection and other requirements based on individual occupancies.

136

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137

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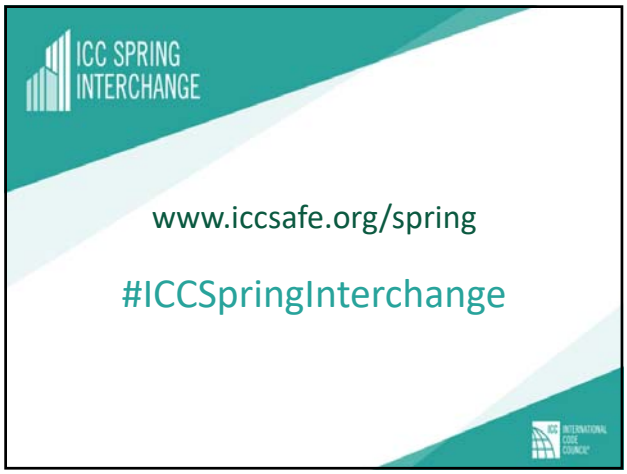
138



139

File Attachments for Item:

EC-5 2021 IBC, IRC, IFC Update (ICC)

All certifications (4 hours)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 IBC, IRC, IFC Update

Course instructor: Doug Thornburg, Terrell Stripling

Course description: This session will identify important changes from the 2018 to 2021 editions of the International Building Code® (IBC®), International Residential Code® (IRC®) and International Fire Code® (IFC®). Participants will be presented with those changes that will most impact their use of the code when they apply the 2021 IBC, IRC or IFC.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: May 1, 2023 / Tampa Bay, FL

Special Content:

Code Administration:_____
Existing Buildings: _____
Electrical Instruction: _____
Plumbing Instruction:_____

Conference Course: 2021 IBC, IRC, IFC Update
Conference Name: ICC Spring Interchange
Conference location: Tampa Bay, FL

Course to be offered online? N/A **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2021 IBC, IFC and IRC Update

Description

Overview of the key changes from the 2018 to the 2021 editions of the International Building Code (IBC), International Fire Code (IFC) and International Residential Code (IRC). Identifies changes in organization and code requirements and the applicability of these requirements to design, plan review and inspection. This course provides the attendees with a fundamental review of some of the new and revised requirements that are contained in these three International Codes.

Goal

The goal of *2021 IBC, IFC and IRC Update* is to familiarize building officials, fire officials, plans examiners, inspectors, design professionals, contractors, and others in the design and construction industry with many of the important changes in the 2021 editions of the IBC, IFC and IRC.

This publication is designed to assist those code users in identifying the specific code changes that have occurred and, more importantly, understanding the reason behind the change.

Objectives

Upon completion of this seminar, participants will be better able to:

- Identify the most significant differences between the 2018 and 2021 editions of the IBC, IFC and IRC.
- Identify whether the code change is an addition, deletion, modification or clarification.
- Identify the purpose and intent of the code changes.
- Identify the application of the new and revised design, plan review and inspection requirements.

Outline of Seminar **(4 hours = 240 minutes)**

1) Course overview (10 minutes)
   a) Introductions (5)
   b) Objectives (5)

2) International Building Code (75 minutes)
   a) Definitions (5)
   b) Building Planning (10)
   c) Fire Protection (20)
   d) Accessibility (10)
   e) Structural Provisions (25)
   f) Building Services (5)

3) International Fire Code (75 minutes)
   a) Definitions (10)
   b) General Safety (10)
   c) Building and Equipment Design (35)
   d) Special Occupancies and Operations (15)
   e) Hazardous Materials (5)

4) International Residential Code (75 minutes)
   a) Building Planning (35)
   b) Building Construction (40)

5) Summary and Wrap-up (5 minutes)

Douglas W. Thornburg, AIA, CBO, is currently Vice-President and Technical Director of Products and Services for the International Code Council (ICC) where he provides administrative and technical leadership for the ICC product development activities. Prior to employment with ICC in 2004, he was in private practice as a code consultant and educator on building codes for nine years. Doug also spent ten years with the International Conference of Building Officials (ICBO) where he served as Vice-President/Education.

In his current role, Doug also continues to create and present building code seminars nationally and has developed numerous educational texts and resource materials. He was presented with ICC's inaugural Educator of the Year Award in 2008, recognizing his outstanding contributions in education and training.

A graduate of Kansas State University and a registered architect, Doug has over 36 years of experience in building code training and administration. He has authored a variety of code-related support publications, including the *IBC Illustrated Handbook* and the *Significant Changes to the International Building Code*.

Terrell Stripling

Terrell is a seasoned instructor with over 20 years of fire service experience and has also worked in the construction industry. He holds a B.S. degree from Oklahoma State University in Fire Protection Engineering and Technology. His experience in fire prevention, code management and the ability to effectively communicate a pro-active philosophy is reflected in Terrell's passion for education. At the college level, he has served inn the positions of Department Chair and adjunct professor in the Fire Science Department. He utilizes the theory of the code along with hands-on practical application to achieve ICC's vision of "Protecting the health, safety, and welfare of people creating better buildings and safer communities."

ICC SPRING INTERCHANGE

2021 IBC, IRC and IFC Update

1

Education Sessions
Sponsored By

2

OBJECTIVES

- Identify the differences between 2021 and the 2018 editions.
- Identify changes in format and technical requirements.
- Explain the intent and application of the changes.

3

ICC SPRING INTERCHANGE

2021 International Building Code

4

202 Definition of Mass Timber

- Mass timber is considered as structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross-section dimensions.
- Single term represents both:
  - Heavy-timber designated as Type IV-HT which includes various types of members where fire-resistance is based on minimum dimensions.
  - Mass timber used in new Types IV-A, IV-B and IV-C that must have a fire-resistance rating.

5

202 Definition of Mass Timber

- New definition of *noncombustible protection* addresses the passive fire protection required for mass timber.
- Depending on the building's type of construction, mass timber may have a fire-resistance rating obtained:
  - By its own fire-resistive rating, or
  - Through a combination of the inherent mass timber fire-resistance plus protection with noncombustible insulating materials, or
  - Entirely by the noncombustible protection
- The use of noncombustible protection recognizes its value in delaying the combustion of mass timber members.

6

306.2 Group F-1 Occupancy Classification

- Two new items added to listing of Group F-1 occupancies.
- Energy storage systems (ESS) in dedicated-use buildings.
  - Administrative/support areas without ESS permitted where ≤ 10% of floor area of the story where located
  - In mixed-occupancy buildings, ESS to be classified the same as major occupancy
  - Previously would often be classified as Group H-2, however new IFC provisions address potential hazards to allow for a reduction in occupancy classification.
- Water/sewer treatment plants
  - Typically contain materials in use that would warrant a Group H classification should MAQs be exceeded.

7

307.1.1 Uses Not Classified as Group H

- Two new items have been added to the list of uses that store, use and/or handle hazardous materials but are not to be classified as Group H.
  - Distilling or brewing of alcohol beverages
  - Storage of beer, distilled spirits and wines in barrels and casks
- Removal of Group H status applicable regardless of alcohol content and quantity of liquid.
- IFC has added additional requirements to address hazards, including automatic sprinkler systems in Group F-1 and S-1 fire areas where such liquids are located.

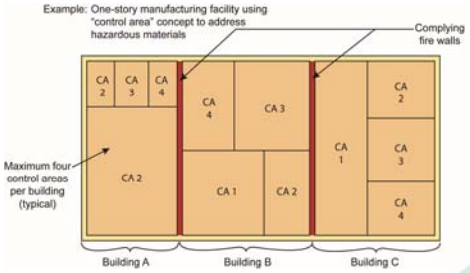
8

414.2.3 Fire Wall Use for Control Areas

- For purposes of determining the number of control areas in a building, each portion separated by one or more fire walls shall be considered a separate building.
  - New allowance permits additional quantities of hazardous materials without classification as a Group H occupancy by increasing the number of control areas permitted in the structure.
- New allowance permits additional quantities of hazardous materials without classification as a Group H occupancy by increasing the number of control areas permitted in the structure.

9

414.2.3 Fire Wall Use for Control Areas



10

Table 504.3 Allowable Height in Feet

- Limits to building height (in feet) have been developed for Types IV-A, IV-B and IV-C construction
- Sprinklered and nonsprinklered options
- Establishment of allowable height started with setting IV-B allowances equivalent to Type IB.
- No unlimited heights for Type IV-A, but typically an increase of 1.5 over Type IV-B.
- Type IV-C generally equivalent to IV-HT limits.
- No additional heights over that permitted for Type IV-HT are permitted for nonsprinklered buildings.

11

TABLE 504.3
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION											
		TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A	B	C	HT	A	B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	270	180	85	85	70	60
H-1, H-2, H-3, H-5	NS[c,d]	UL	160	65	55	65	55	120	90	65	65	50	40
	S												
H-4	NS[c,d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	140	100	85	85	70	60
I-1 Condition 1, I-3	NS[d,e]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	180	120	85	85	70	60
I-1 Condition 2, I-2	NS[d,e,f]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85									
I-4	NS[d,g]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	180	120	85	85	70	60
R[h]	NS[d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S13D	60	60	60	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	270	180	85	85	70	60

No changes to footnotes.

Sprinklered: IV-B = I-B & IV-A = 1.5 x IV-B with exceptions

12

Table 504.4 Allowable Height in Stories

- Limits to number of stories above grade plane have been established for Types IV-A, IV-B and IV-C construction.
- Rationale for story limits similar to that for height in feet.
- Where building is not sprinklered:
  - Limits on stories same as that allowed for Type IV-HT.
- Consistent with allowable height in feet and allowable floor area, each occupancy reviewed individually to address specific hazards that would warrant a variance from the established process.

13

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a, b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION											
		TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A	B	C	HT	A	B
A-1	NS	UL	5	3	2	3	2	3	3	3	3	2	1
	S	UL	6	4	3	4	3	9	6	4	4	3	2
A-2	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-3	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-4	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-5	NS	UL	UL	UL	UL	UL	UL	1	1	1	UL	UL	UL
	S	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	11	5	3	5	3	5	5	5	5	3	2
	S	UL	12	6	4	6	4	18	12	9	6	4	3
S-1	NS	UL	11	4	2	3	2	4	4	4	4	3	1
	S	UL	12	5	34	4	34	10	7	5	5	4	2
S-2	NS	UL	11	5	3	4	3	4	4	4	4-5	4	2
	S	UL	12	6	4	5	4	12	8	5	5-6	5	3

Sprinklered: IV-B = I-B & IV-A = 1.5 x IV-B with exceptions

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Table 506.2 Allowable Building Area

- Limits to building floor areas have been developed for Types IV-A, IV-B and IV-C.
- No unlimited area permitted for any of Type IV classifications.
- Initially, allowable area factors for Type IV-HT construction were increased by following multipliers:
  - Type IV-C: x 1.25
  - Type IV-B: x 2.00
  - Type IV-A: x 3.00
- Factors then re-examined on a case-by-case basis regarding their relative hazard and occupancy classification.

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ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, S13D OR SM, as applicable) IN SQUARE FEET[a,b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION											
		TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A 3xHT	B 2xHT	C 1.25xHT	HT	A	B
I-1	NS[d,e]	UL	55,000	19,000	10,000	16,500	10,000	54,000	36,000	18,000	18,000	10,500	4,500
	S1	UL	220,000	76,000	40,000	66,000	40,000	216,000	144,000	72,000	72,000	42,000	18,000
	SM	UL	165,000	57,000	30,000	49,500	30,000	162,000	108,000	54,000	54,000	31,500	13,500
I-2	NS[d,f]	UL	UL	15,000	11,000	12,000	NP	36,000	24,000	12,000	12,000	9,500	NP
	S1	UL	UL	60,000	44,000	48,000	NP	144,000	96,000	48,000	48,000	38,000	NP
	SM	UL	UL	45,000	33,000	36,000	NP	108,000	72,000	36,000	36,000	28,500	NP
I-3	NS[d,e]	UL	UL	15,000	10,000	10,500	7,500	36,000	24,000	12,000	12,000	7,500	5,000
	S1	UL	UL	60,000	40,000	42,000	30,000	144,000	96,000	48,000	48,000	30,000	20,000
	SM	UL	UL	45,000	30,000	31,500	22,500	108,000	72,000	36,000	36,000	22,500	15,000
I-4	NS[d,g]	UL	60,500	26,500	13,000	23,500	13,000	76,500	51,000	25,500	25,500	18,500	9,000
	S1	UL	121,000	106,000	52,000	94,000	52,000	306,000	204,000	102,000	102,000	74,000	36,000
	SM	UL	181,500	79,500	39,000	70,500	39,000	229,500	153,000	76,500	76,500	55,500	27,000
M	NS	UL	UL	21,500	12,500	18,500	12,500	61,500	41,000	25,625	20,500	14,000	9,000
	S1	UL	UL	86,000	50,000	74,000	50,000	246,000	164,000	102,500	82,000	56,000	36,000
	SM	UL	UL	64,500	37,500	55,500	37,500	184,500	123,000	76,875	61,500	42,000	27,000

General approach with exceptions.

16

506.3.2 Allowable Area Frontage Increase

- Methodology for determining allowable area increase for open frontage has been simplified through use of a tabular format.
- Table 506.3.3 based on two criteria:
  - Smallest public way or open space that ≥ 20 feet, and
  - Percentage of building perimeter having ≥ 20 feet of public way and/or open space
- Allowance for weighting the open space area increase has been eliminated
  - Interpolation within Table 506.3.3 is permitted

17

506.3.2 Allowable Area Frontage Increase

- Resulting frontage increase intended to be consistent with increase determined by previous method
  - In some cases, greater frontage increases are provided as compared to past methodology

TABLE 506.3.3 Frontage Increase Factor[a]

Percentage of Building Perimeter	Open Space			
	0 to less than 20 Feet	20 to less than 25 Feet	25 to less than 30 Feet	30 Feet or greater
0 to less than 25	0	0	0	0
25 to less than 50	0	0.17	0.21	0.25
50 to less than 75	0	0.33	0.42	0.50
75 to 100	0	0.50	0.63	0.75

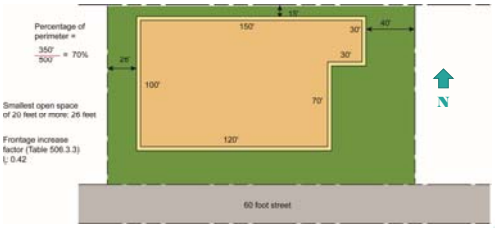
a. Interpolation is permitted.

- Under certain circumstance, a greater frontage increase may be available to the designer if one or more open spaces not recognized when applying Table 506.3.3 or 506.3.3.1

18

506.3.2 Allowable Area Frontage Increase

- EXAMPLE:



Note: If west open space is ignored, I_f would be 0.50 based on 50% of perimeter open with smallest open space of ≥ 30 feet

19

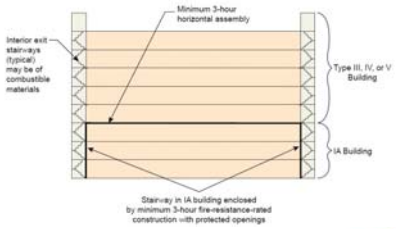
510.2 Stairway Construction in Podium Buildings

- Stairway construction in Type IA (lower) portion of podium buildings now permitted to be of combustible materials where two conditions exist:
  - Upper building is of Type III, IV or V construction, and
  - Stairway in lower building enclosed by minimum 3-hour fire-resistance-rated construction (shaft enclosure) with protected openings.
- Addresses confusion on how to address stairway construction that connects combustible and noncombustible portions of a podium building.
  - Section 1011.7 indicates stairways to be built of materials permitted based on building's type of construction.

20

510.2 Stairway Construction in Podium Buildings

- Stairway is conceptually located totally within upper Type III, IV or V building, thus allowing for combustible stairway construction.
  - Minimum 3-hour fire-resistance-rated separation fully separates "combustible" construction from "noncombustible" construction.



21

Table 601 Type IV Fire-Resistance

- Table 601 identifying minimum fire-resistance rating for building elements based on type of construction has been expanded to include new Type IV-A, IV-B and IV-C buildings.
- General comparison with Type IA (IV-A) and Type IB (IV-B and IV-C).
- Also clarifies that heavy timber roof construction, including primary structural frame members, permitted in: Type IB, IIA, IIB, IIIA and VA buildings.
  - Allows for nonrated combustible roof construction

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TABLE 601 Fire-Resistance Rating Requirements for Building Elements (Hours)

Building Element	Type I A	Type I B	Type II A	Type II B	Type III A	Type III B	Type IV A	Type IV B	Type IV C	Type IV HT	Type V A	Type V B
Primary structural frame[f]	3[a,b]	2[a,b,g]	1[b,g]	0[g]	1[b,g]	0	3[g]	2[g]	2[g]	HT	1[b,g]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[g]	2[g]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 602 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1½	1	1	HT	1[b,c]	0

c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.

g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire-resistance rating of not less than 1 hour.

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602.4 Mass Timber Type IV Buildings

- Type IV-A, IV-B and IV-C buildings may be constructed of mass timber and noncombustible materials.
- Required fire-resistance ratings may come from mass timber, noncombustible protection, or both.
  - Protective material to be applied directly to the timber members
  - Assigned time determined per Sections 703.2 and 722.7
- For Type IV-HT construction, minimum timber member dimensions of Section 2304.11 continue to be applicable.

24

602.4 Mass Timber Type IV Buildings

- Limited changes to existing heavy timber provisions now designated as Type IV-HT.
- Combustible concealed spaces permitted in all Type IV categories where in conformance with Sections 602.4.1 through 602.4.4.
- Publication "*Mass Timber Buildings and the IBC*" by ICC and AWC addresses Type IV construction in detail.

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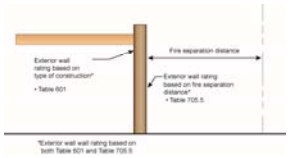
602.4.1- 602.4.3 Type IV-A, IV-B and IV-C Buildings

- Type IV-A construction mandates that faces of all timber members be protected with noncombustible materials.
  - Noncombustible wall and ceiling protection to contribute a time per Table 722.7.1(1), but not less than 80 minutes.
  - Floor assembly to be protected with noncombustible material at least 1 inch thick on top.
- Type IV-B construction mandates similar protection, but only required on an established percentage of members.
  - Some degree of exposed timber permitted
- Type IV-C construction permits all timber members to be unprotected.

26

Table 705.5 Exterior Wall Ratings

- Previous Table 602 addressing "Fire-resistance Rating Requirements for Exterior Walls Based on Fire Separation Distance" has been relocated.
- Relocation is deemed appropriate as Chapter 7 is the primary location for establishing exterior wall requirements related to fire-resistance.
- In addition, entries have been made for new construction types IV-A, IV-B and IV-C.



27

TABLE ~~602~~ 705.5 Fire-Resistance Rating Requirements for Exterior Walls Based on Fire Separation Distance[a,d,g]

Fire Separation Distance = X (feet)	Type Of Construction	Occupancy Group H[e]	Occupancy Group F-1, M, S-1[f]	Occupancy Group A, B, E, F-2, I, R[f], S-2, U[h]
X < 5[b]	All	3	2	1
5 ≤ X < 10	IA, IV-A Others	3 2	2 1	1 1
10 ≤ X < 30	IA, IB, IV-A, IV-B IIB, VB Others	2 1 1	1 0 1	1[c] 0 1[c]
X ≥ 30	All	0	0	0

For SI: 1 foot = 304.8 mm.

(footnotes not shown)

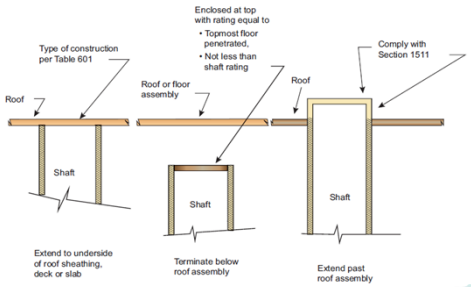
28

713.12 Top of Shaft Enclosure

- Three specific methods for terminating a shaft enclosure at the top have been established to clarify the options that are available:
  - Extend the shaft walls to the underside of the roof sheathing, deck or slab, or
  - Terminate below the roof assembly with a top enclosure having the same fire-resistance rating as the topmost floor penetrated by the shaft but not less that the required rating of the shaft enclosure, or
  - Extend past the roof assembly and comply with the provisions for rooftop structures (penthouses) in Section 1511.

29

713.12 Top of Shaft Enclosure



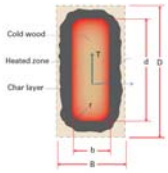
30

722.1 Fire-Resistance Rating of Exposed Mass Timber Members

- The fire-resistance rating of mass timber members is to be in conformance with Chapter 16 of the *National Design Specification for Wood Construction* (NDS).
- NDS 16.2 addresses fire design up to 2 hours
- Applicable to beams, columns, walls, floors/roofs
- Applicable products include:
  - Sawn lumber
  - Glulam (softwood)
  - LVL
  - PSL
  - LSL
  - CLT

31

722.1 Fire-Resistance Rating of Exposed Mass Timber Members



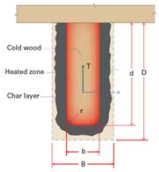


Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

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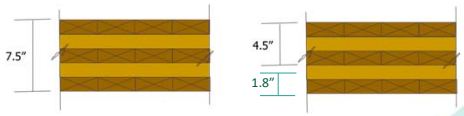
722.7 Fire-Resistance Rating of Mass Timber

Example of determination of effective CLT roof cross-section:

- Assume 5-layers @ 1.5" (total = 7.5")
- Determine thickness for 1-hr FRR
- a_{char} = 1.8" (NDS Table 16.2.1B)
- d = 7.5" – 1.8" = 5.7"
- Will typically assume 3-layer panel for design capacity
  - Layer second from bottom ineffective in one-way panels



33

722.7 Fire-Resistance Rating of Mass Timber Assemblies

- A prescriptive approach has been provided to achieve the required fire-resistance ratings for mass timber members and assemblies.
- The fire-resistant rating to consist of the rating of the unprotected mass timber element added to the protection time of the noncombustible protection.
  - At least 2/3 of the required fire-resistance rating must come from the noncombustible protection.
- Provisions address protection on both exterior and interior surfaces.
- The fire-resistance rating of exposed mass timber members is to be in conformance with Chapter 16 of the *National Design Specification for Wood Construction* (NDS).

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TABLE 722.7.1(1) Protection Required from Noncombustible Covering Material

Required Fire-Resistance Rating of Building Element per Tables 601 and 705.5 (hours)	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

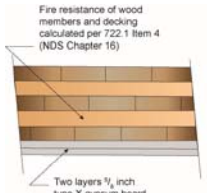
TABLE 722.7.1(2) Protection Provided by Noncombustible Covering Material

Noncombustible Protection	Protection Contribution (minutes)
½-inch Type X gypsum board	25
⅝-inch Type X gypsum board	40

35

722.7 Fire-Resistance Rating of Mass Timber Assemblies

- Example:



CLT time = 50 minutes
5/8" Type X = 40 minutes
5/8" Type X = 40 minutes

Total 130 minutes

(acceptable for 2-hour rating)

36

1102 Accessible Design Compliance

- The ICC A117.1 standard as referenced by the IBC for the design and construction of accessible buildings and facilities has been updated from the 2009 edition to the 2017 edition.
- Many of the major revisions are addressed in the ICC publication *Significant Changes to the ICC A117.1 Accessibility Standard*, 2017 Edition, including:
  - Enhanced dimensions for clear floor spaces and turning spaces.
  - Modifications to exterior routes, curb cuts, blended transitions, detectable warnings, passenger drop-offs and parking facilities.

37

1105.1.1 Automatic Doors at Public Entrances

- In specified occupancies with sizable occupant loads, the accessible public entrances must now be provided with an automatic door.
  - Where an automatic door is required by Table 1105.1.1, it shall be either a full power-operated door or a low-energy power-operated door.

TABLE 1105.1.1 Public Entrance with Power-Operated Door[a]

Occupancy	Building Occupant Load Greater Than
A-1, A-2, A-3, A-4	300
B, M, R-1	500

a. In mixed-use facilities where the total sum of the building occupant load is greater than those listed, the most restrictive building occupant load shall apply.

38

1105.1.1 Automatic Doors at Public Entrances

- In mixed-occupancy buildings where total building occupant load exceeds that listed, the most restrictive building occupant load shall apply, for example:
  - Where Group B has OL of 300 and Group A-3 has OL of 100, total OL of 400, automatic door required based on Group A-3 tabular threshold.
  - Where Group B has OL of 450 and Group E has OL of 60, total OL of 510, automatic door required based on Group B tabular threshold.
- Where the public entrance includes a vestibule, at least one door into and one door out of the vestibule must comply with the requirements.

39

1108.5, 1110.2 Assisted Toileting and Bathing

- Changes have been made to the provisions for nursing homes and assisted living facilities to allow some units to have toilet and bathing facilities designed for assisted use.
  - These allowances are permitted instead of the independent use facilities generally intended by the ICC A117.1 Accessible unit provisions.
- Both scoping and technical provisions are provided in IBC.
- The assisted use provisions are optional and can be applied when desired by the designer.
  - Units may be modified for toileting, bathing or both

40

1108.5, 1110.2 Assisted Toileting and Bathing

- Assisted water closets and roll-in-type showers may replace like fixtures in up to **50**% of Accessible units in the following occupancies:
  - Group I-1, Conditions 1 and 2
  - Group I-2 rehabilitation facilities
- Assisted water closets and roll-in-type showers may replace like fixtures in up to **90%** of Accessible units in the following occupancies:
  - Group I-2 nursing homes

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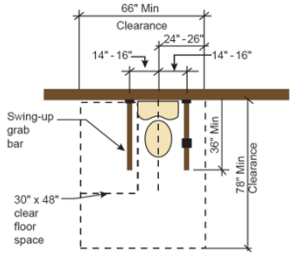
1108.5, 1110.2 Assisted Toileting



- Primary technical changes include:
  - Increased clearance around water closet of 66" with clearance of 24" to 26" from centerline of fixture
  - Increased clearance depth of 78" to allow for additional approach options
  - Allowance for swing-up grab bars that are typically only permitted in Type B units
  - Toilet paper dispenser to be installed on at least one of the swing-up grab bars

42

1108.5, 1110.2 Assisted Bathing

Assisted bathing roll-in shower-using exceptions

- Primary technical change is elimination of required folding seat
- Allows for use of rolling chair when necessary
- Sidewall and backwall grab bars now differ, with side-wall bar required on 'seat wall' and both grab bars starting in corners

43

1207 Enhanced Classroom Acoustics

- In Group E occupancies, enhanced classroom acoustics shall be provided in all classrooms having a volume of 20,000 cubic feet or less.
- Intended to apply to standard-sized self-contained classrooms, but not larger spaces for activities such as band or choir.
  - Also not intended to apply to ancillary spaces, such as individual tutoring rooms, corridors, or a cafeteria.
- Good acoustics are essential to support language acquisitions and learning for all children.
- Assistive technologies typically only amplify the teacher and do not amplify discussions between students or between teacher and individual student.

44

1207 Enhanced Classroom Acoustics

- Such acoustics to be in compliance with Section 808 of ICC A117.1, including regulation of:
  - Reverberation times based on either the performance method or prescriptive method
  - Ambient sound levels from sources both inside and outside of the classroom
- In addressing reverberation times, both performance and prescriptive methods are available.
- Ambient sound levels not to exceed 35 dBA and 55 dBC

45

1406.10 Metal Composite Material (MCM) Cladding

- Metal composite materials (MCM) and systems installed on buildings of Type I, II, III and IV construction are now regulated based upon one of two conditions:
  - Such installations that are over 40 feet above grade plane must comply with:
    - Surface-burning characteristics
      - Flame spread index $\leq$ 25
      - Smoke developed index $\leq$ 450
    - Thermal barrier separation
      - Minimum ½" gypsum board or test per NFPA 275
    - Acceptance criteria of NFPA 285
      - Addresses exterior nonload-bearing wall assemblies containing combustible components
  - Such installations that do not exceed 40 feet above grade plane need only comply with surface-burning characteristics and thermal barrier separation.

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1406.10 Metal Composite Material (MCM) Cladding

- Previously, all MCM cladding on buildings of other than Type V to meet all three conditions, or meet alternative conditions of Section 1406.11
- Allowance for use of alternative conditions has been deleted, thus removing issues addressing:
  - Fire separation distance
  - MCM surface area limitation and separation
  - Sprinkler protection throughout building
- Modification addresses any confusion in the various requirements, as well as eliminating allowances previously provided where building is sprinklered.

47

1504.9 Aggregate-surfaced Roof

- Minimum parapet heights have been established for aggregate-surfaced roofs to prevent blow-off.
- New Table 1504.9 now mandates minimum heights based on:
  - Aggregate size
  - Mean roof height
  - Wind exposure
  - Basic design wind speed
- Provides engineering and scientific basis for roof design to prevent blow-off based on wind tunnel tests and subsequent field studies of hurricane damage.

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1504.9 Aggregate-surfaced Roof

- Past provisions were not based on a quantitative analysis of observed roofing system performances on real wind events, but rather variations in surface pressure with building height
- Table 1504.8 previously either permitted or prohibited aggregate used as surfacing for roof coverings or ballast solely based on:
  - Maximum mean roof height
  - Design wind load
  - Exposure category
- Conditions where no parapets are provided are no longer allowed

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TABLE 1504.9 Minimum Required Parapet Height (inches) for Aggregate Surfaced Roofs[a,b,c]

Aggregate Size	Mean Roof Height (ft)	Wind Exposure and Basic Design Wind Speed (mph)																	
		Exposure B									Exposure C[d]								
		≤95	100	105	110	115	120	130	140	150	≤95	100	105	110	115	120	130	140	150
ASTM D1863 (No.7 or No.67)	15	2	2	2	2	12	12	16	20	24	2	13	15	18	20	23	27	32	37
	20	2	2	2	2	12	14	18	22	26	12	15	17	19	22	24	29	34	39
	30	2	2	2	13	15	17	21	25	30	14	17	19	22	24	27	32	37	42
	50	12	12	14	16	18	21	25	30	35	17	19	22	25	28	30	36	41	47
	100	14	16	19	21	24	27	32	37	42	21	24	26	29	32	35	41	47	53
	150	17	19	22	25	27	30	36	41	46	23	26	29	32	35	38	44	50	56
ASTM D1863 (No.8)	15	2	2	2	2	12	12	12	15	18	2	2	2	13	15	17	22	26	30
	20	2	2	2	2	12	12	13	17	21	2	2	12	15	17	19	23	28	32
	30	2	2	2	2	12	12	16	20	24	2	12	14	17	19	21	26	31	35
	50	12	12	12	12	14	16	20	24	28	12	13	17	19	22	24	29	34	39
	100	12	12	14	16	19	21	26	30	35	16	18	21	24	26	29	34	39	45
	150	12	14	17	19	22	24	29	34	39	18	21	23	26	29	32	37	43	48

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 mile per hour = 0.447 m/s.

a. Interpolation shall be permitted for mean roof height and parapet height.

b. Basic design wind speed, V, and wind exposure shall be determined in accordance with Section 1609.

c. Where the minimum required parapet height is indicated to be 2 inches (51 mm), a gravel stop shall be permitted and shall extend not less than 2 inches (51 mm) from the roof surface and not less than the height of the aggregate.

d. For Exposure D, add 8 inches (203 mm) to the parapet height required for Exposure C and the parapet height shall not be less than 12 inches (305 mm).

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1704.6 Structural Observations

- Two new classes of structures are now required to be provided with structural observation:
  - Structures classified as Risk Category III (previously limited only to RC IV structures), and
  - Structures in SDC E that are more than two stories above grade plane (no previous requirement based upon SDC)
- Recognizes substantial hazards that may be present in facilities considered as RC III structures, as well as those structural hazards involving multi-story structures in SDC E.

51

1705.5.3 Mass Timber Special Inspection – Construction

- Applicable only to Type IV-A, IV-B and IV-C construction, special inspection requirements have been added to address the anchorage and connection of mass timber structural elements.
- Inspections are similar to requirements for other prefabricated systems, such as precast concrete and structural steel.
- Additional special inspections may be required by the building official for any work unusual in its nature.

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TABLE 1705.5.3 Required Special Inspections of Mass Timber Construction

Type	Continuous Special Inspection	Periodic Special Inspection
1. Inspection of anchorage and connections of mass timber construction to timber deep foundation systems.		X
2. Inspect erection of mass timber construction.		X
3. Inspection of connections where installation methods are required to meet design loads.		
Threaded fasteners.		
Verify use of proper installation equipment.		X
Verify use of pre-drilled holes where required.		X
Inspect screws, including diameter, length, head type, spacing, installation angle, and depth.		X
Adhesive anchors installed in horizontal or upwardly inclined orientation to resist sustained tension loads.	X	
Adhesive anchors not defined in the preceding cell.		X
Bolted connections.		X
Concealed connections.		X

53

1705.18 Firestop Inspection in Group R Occupancies

- In Group R fire areas with an occupant load > 250, special inspection is now required for the installation of:
  - Firestops
  - Fire-resistant joint systems
  - Perimeter fire containment systems
- Provides greater assurance that such fire protective features are properly installed where large residential occupant loads are anticipated.

54

Questions?

55

ICC SPRING INTERCHANGE

2021 International Residential Code

56

R102.7.1 Additions, Alterations or Repairs

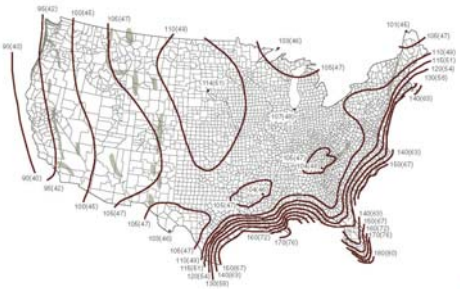
- Not cause an existing building to be less compliant with the code
- Comply with height limits of IRC
- Where alteration causes use or occupancy to be changed to one not within the scope of IRC, the provisions of the IEBC apply.

57

R301.2.1 Wind Design

- Updated Wind Speed maps match IBC and ASCE 7 maps with a large portion of the country having wind speeds less than 115 mph.

58



59

Table R301.2.1(1) Components and Cladding

- Component and cladding wind pressures in Table R301.2.1(1) are updated for new design wind speeds and hip or gable roof profiles.

60

Table R301.2.1(1) Components and Cladding

	Zone	Effective Wind Areas (ft^2)	Ultimate Design Wind Speed, V_{ult}													
			90		95		100		105		110		...		180	
			Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg
Gable Roof >7 to 20 degrees	1, 2e	10	5.4	-16.2	6	-18.0	6.7	-19.9	7.4	-22	8.1	-24.1	...	...	21.6	-64.6
	1, 2e	20	4.9	-16.2	5.4	-18	6.0	-19.9	6.6	-22	7.2	-24.1	...	...	19.4	-64.6
	1, 2e	50	4.1	-9.9	4.6	-11	5.1	-12.2	5.6	-13.4	6.1	-14.7	...	...	16.4	-39.4
	1, 2e	100	3.6	-5	4	-5.6	4.4	-6.2	4.8	-6.9	5.3	-7.5	...	...	14.2	-20.2
	2n, 2r, 3e	10	5.4	-23.6	6	-26.3	6.7	-29.1	7.4	-32.1	8.1	-35.2	...	...	21.6	-94.2
	2n, 2r, 3e	20	4.9	-20.3	5.4	-22.7	6	-25.1	6.6	-27.7	7.2	-30.4	...	...	19.4	-81.4
	2n, 2r, 3e	50	4.1	-16	4.6	-17.9	5.1	-19.8	5.6	-21.8	6.1	-24	...	...	16.4	-64.2
	2n, 2r, 3e	100	3.6	-12.8	4	-14.3	4.4	-15.8	4.8	-17.4	5.3	-19.1	...	...	14.2	-51.3
	3r	10	5.4	-28	6	-30.2	6.7	-34.6	7.4	-38.1	8.1	-41.8	...	...	21.6	-112
	3r	20	4.9	-24	5.4	-26.7	6	-29.6	6.6	-32.7	7.2	-35.9	...	...	19.4	-96
	3r	50	4.1	-18.7	4.6	-20.8	5.1	-23.1	5.6	-25.4	6.1	-27.9	...	...	16.4	-74.7
	3r	100	3.6	-14.7	4	-16.3	4.4	-18.1	4.8	-20	5.3	-21.9	...	...	14.2	-58.7

61

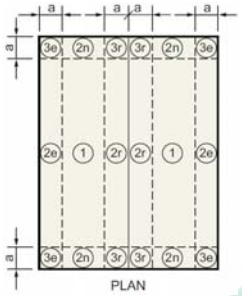
New vocabulary includes division of C&C corner and edge zones as follows:

- 2 – edge zones
- 2e – edge zone along bottom of roof above the soffit
- 2r – edge zone along roof peak
- 2n – edge zone along rake edge of gable roofs

- 3 – corner zones
- 3e – corner zone at bottom of roof above the soffit
- 3r – corner zone at roof peak

C&C interior zones:
1 – interior zone

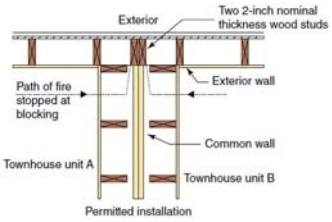
a = 4 feet



62

R302.2 Townhouse Common Wall

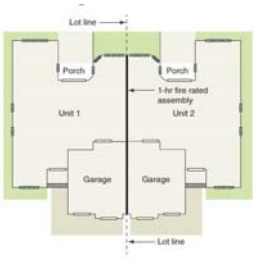
- Common walls separating townhouses can terminate at the inside of exterior walls:
  - Two 2-inch studs as fireblocking



63

R302.3 Two-Family Dwelling Separation

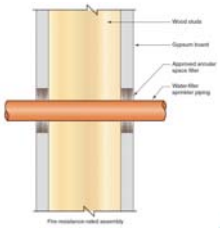
- One-hour separation whether or not a lot line exists between units



64

R302.4 Dwelling Unit Rated Penetrations

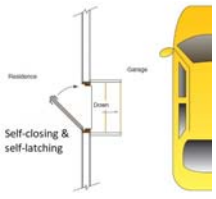
- Water-filled fire sprinkler piping of any approved material
  - does not require a firestop system
  - provided annular space is filled with the prescribed materials



65

R302.5 Dwelling-Garage Opening Protection

- Door between the garage and residence must be self-latching.



66

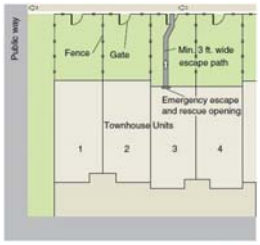
R303.1 Mechanical Ventilation

- Whole-house mechanical ventilation system or a mechanical ventilation system capable of producing 0.35 ACH in habitable rooms
- A local exhaust system is an acceptable substitute for natural ventilation in kitchens.

67

R310.1 Emergency Escape and Rescue Opening Required

- Emergency escape and rescue openings require a clear 36-inch-wide path to a public way.
- Operation requirements have been clarified.



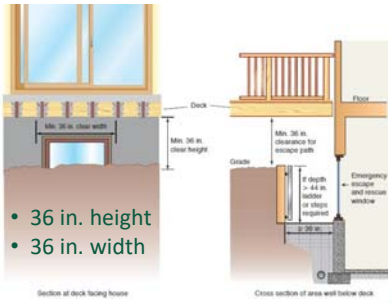
68

R310.2 Emergency Escape and Rescue Openings

- Emergency escape openings under decks, porches and cantilevers require a path not less than 36 in. in height and 36 in. in width.
- Dimensions have been clarified (placed in separate sections):
  - Minimum opening area
  - Minimum opening dimensions
  - Maximum ~~sill~~ height above floor

69

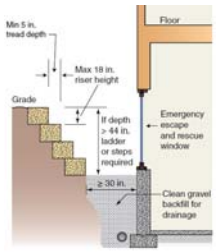
R310.2 Emergency Escape and Rescue Openings (continued)



70

R310.3, R310.4 EERO Area Wells

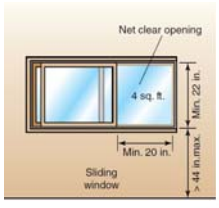
- Window wells and area wells merged into area wells.
- Dimensions are given for steps:
  - 5-inch minimum tread
  - 18-inch maximum rise
  - 12-inch minimum width



71

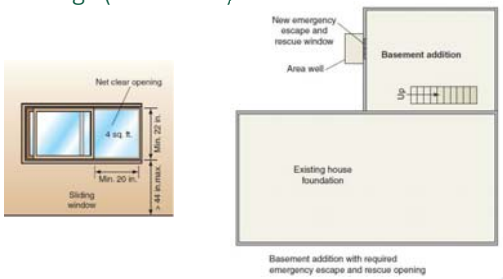
R310.5, R310.6, R310.7 EERO in Existing Buildings

- 4 sf minimum clear opening permitted for EERO where:
  - Basement remodel
  - Basement addition
  - Change of occupancy



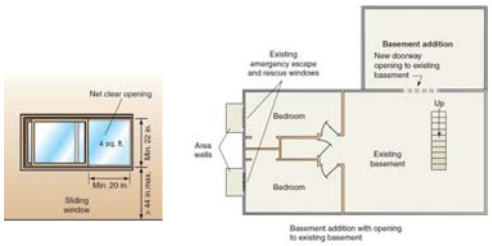
72

R310.5, R310.6, R310.7 EERO in Existing Buildings (continued)



73

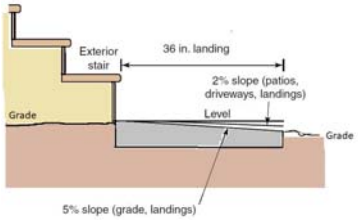
R310.5, R310.6, R310.7 EERO in Existing Buildings (continued)



74

R311.7.7 Stairway and Landing Walking Surface

- New exception allows steeper slopes for exterior landings that also serve to drain surface water away from the building.



75

R314.3 Smoke Alarm Locations

- A new location requirement addresses high ceilings adjacent to hallways serving bedrooms.

76

R315.2.2 Carbon Monoxide Alarms

- Repairs to an existing fuel-fired mechanical system now trigger the retroactive requirements for carbon monoxide alarms.

77

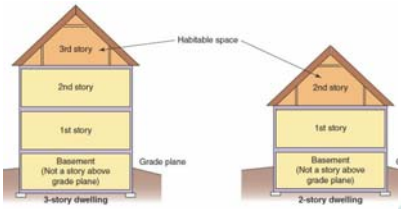
R324.6 Photovoltaic Systems

- Building-integrated photovoltaic (BIPV) systems meeting the specified criteria do not require firefighter access pathways and setbacks.

78

R326 Habitable Attics

- Habitable space above 2nd story or 1st story meets definition of story – no additional requirements



79

Table R403.1(1) Footing Width and Thickness

- Minimum footing size tables have been revised to more accurately reflect current practice.
- A 20 psf roof live load or 25 psf ground snow load are the lowest load assumed for the footing.

80

Table R403.1(1) Footing Width and Thickness excerpt

Ground Snow Load or Roof Live Load	Story and Type of Structure with Light Frame	Load Bearing Value of Soil (psf)					
		1500	2000	2500	3000	3500	4000
20 psf Roof Live Load or 25 psf Ground Snow Load	1 story - slab on grade	12x6	12x6	12x6	12x6	12x6	12x6
	1 story - with crawl space	12x6	12x6	12x6	12x6	12x6	12x6
	1 story - plus basement	16x6 ~~18x6~~	12x6 ~~14x6~~	12x6	12x6	12x6	12x6
	2 story - slab on grade	13x6 ~~12x6~~	12x6	12x6	12x6	12x6	12x6
	2 story - with crawl space	15x6 ~~16x6~~	12x6	12x6	12x6	12x6	12x6
	2 story - plus basement	19x6 ~~22x6~~	14x6 ~~16x6~~	12x6 ~~13x6~~	12x6	12x6	12x6
30 psf	1 story - slab on grade	12x6	12x6	12x6	12x6	12x6	12x6
	1 story - with crawl space	13x6	12x6	12x6	12x6	12x6	12x6
	1 story - plus basement	16x6 ~~19x6~~	12x6 ~~14x6~~	12x6	12x6	12x6	12x6
	2 story - slab on grade	13x6 ~~12x6~~	12x6	12x6	12x6	12x6	12x6
	2 story - with crawl space	16x6 ~~17x6~~	12x6 ~~13x6~~	12x6	12x6	12x6	12x6
	2 story - plus basement	19x6 ~~23x6~~	14x6 ~~17x6~~	12x6 ~~14x6~~	12x6	12x6	12x6

81

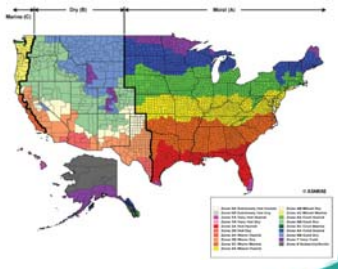
R406.2 Foundation Waterproofing

- Six-mil polyvinyl chloride and polyethylene fabrics have been removed from the list of approved waterproofing materials.

82

R408.8 Under-floor Vapor Retarder

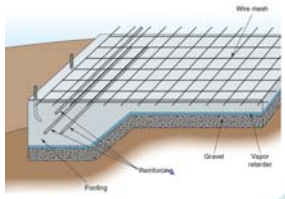
- A Class I or II vapor retarder is required on exposed air permeable insulation between floor joists in Climate Zones 1A, 2A and 3A.



83

R506.2.3 Vapor Retarder

- Thicker vapor retarders are now required below slabs on grade.
- Minimum 10 mil (0.01 inch) thick



84

R507.3 Deck Footings

- Footings for freestanding decks on or near the ground have been clarified.

85

Table R507.3.1 Minimum Footing Size for Decks

LIVE OR GROUND SNOW LOAD (psf)	TRIBUTARY AREA (sq. ft.)	SOIL BEARING CAPACITY 1500 psf		
		Side of a square footing (inches)	Diameter of a round footing (inches)	Thickness (inches)
40	5	7	8	6
	20	10	12	6
	40	14	16	6
50	5	7	8	6
	20	11	13	6
	40	15	17	6
60	5	7	8	6
	20	12	14	6
70	5	7	8	6
	20	12	14	6

86

R507.4 Deck Posts

- The deck post height table has been expanded by adding the tributary area supported by a post and the wood species for determination of maximum post height.

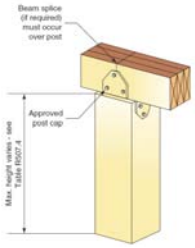


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Table R507.4 Deck Post Height

Loads (psf)	Post Species	Post Size	Tributary Area (ft^2) 20	40	60	80	100	120	140	160
			Maximum Deck Post Height (feet-inches)							
50 Ground Snow Load	Southern Pine	4 x 4	14-0	12-2	9-10	8-5	7-5	6-7	5-11	5-4
		4 x 6	14-0	14-0	12-6	10-9	9-6	8-7	7-10	7-3
		6 x 6	14-0	14-0	14-0	14-0	14-0	14-0	14-0	13-4
		8 x 8	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0
	Douglas Fir, Hem-fir, SPF	4 x 4	14-0	12-1	9-8	8-2	7-1	6-2	5-3	4-2
		4 x 6	14-0	14-0	12-4	10-7	9-4	8-4	7-7	6-11
		6 x 6	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12-10
		8 x 8	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0
	Redwood, W. Cedars, Pond. Pine, Red Pine	4 x 4	14-0	11-8	9-0	6-10	3-7	NP	NP	NP
		4 x 6	14-0	14-0	12-0	10-0	8-6	7-0	5-3	NP
		6 x 6	14-0	14-0	14-0	14-0	14-0	14-0	10-8	2-4
		8 x 8	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0

88

R507.5 Deck Beams

- The deck beam span table has been split into multiple tables providing spans for given deck live or snow loads. Single and multi-ply spans as well as options for cantilevered deck joists are listed.

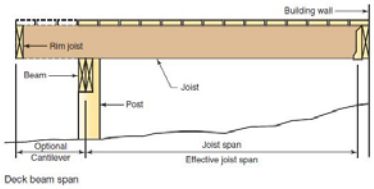

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Table R507.5(2) Max. Deck Beam Span – 50 psf Ground Snow Load

Beam Species	Beam Size	Effective Deck Joist Span Length (feet) 6	8	10	12	14	16	18
		Maximum Beam Span (feet-inches)						
Southern Pine	1-2x6	4-6	3-11	3-6	3-2	2-11	2-9	2-7
	1-2x8	5-9	4-11	4-5	4-0	3-9	3-6	3-3
	1-2x10	6-9	5-10	5-3	4-9	4-5	4-2	3-11
	1-2x12	8-0	6-11	6-2	5-8	5-3	4-11	4-7
	2-2x6	6-8	5-9	5-2	4-9	4-4	4-1	3-10
	2-2x8	8-6	7-4	6-7	6-0	5-7	5-2	4-11
	2-2x10	10-1	8-9	7-10	7-1	6-7	6-2	5-10
	2-2x12	11-11	10-3	9-2	8-5	7-9	7-3	6-10
	3-2x6	7-11	7-2	6-6	5-11	5-6	5-1	4-10
	3-2x8	10-5	9-3	8-3	7-6	6-11	6-6	6-2
	3-2x10	12-8	10-11	9-9	8-11	8-3	7-9	7-3
	3-2x12	14-11	12-11	11-6	10-6	9-9	9-1	8-7

90

R703.2, R703.7.3 Water-resistive Barriers

- WRB material options include:
  - No. 15 felt complying with ASTM D226, Type 1
  - ASTM E2556, Type I or II
  - ASTM E331
  - Other approved materials
- WRB requirements for dry climates versus wet climates defined for stucco.

91

R704 Soffits

- Requirements for soffit material and installation are expanded in a new section.

92

R704 Soffits

- R704.1 General wind limitations
- R704.2 Soffit installation where the design wind pressure is 30 psf or less
- R704.2.1 Vinyl soffit panels
- R704.2.2 Fiber-cement soffit panels
- R704.2.3 Hardboard soffit panels
- R704.2.4 Wood structural panel soffit
- R704.3 Soffit installation where the design wind pressure exceeds 30 psf
- R704.3.1 Vinyl soffit panels
- R704.3.2 Fiber-cement soffit panels
- R704.3.3 Hardboard soffit panels
- R704.3.4 Wood structural panel soffit

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Figure R704.2.1(1) Single Span Vinyl Soffit Panel Support

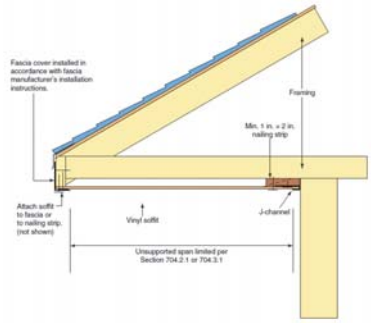

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Table R704.3.4 Prescriptive Alternative Nailing for a WSP Soffit

Maximum Design Pressure (+ or - psf)	Minimum Panel Span Rating	Minimum Panel Performance Category	Nail Type and Size	Fastener[a] Spacing Along Edges and Intermediate Supports	
				Galvanized Steel	Stainless Steel
30	24/0	3/8	6d box (2 x 0.099 x 0.266 head diameter)	6[f]	4
40	24/0	3/8	6d box (2 x 0.099 x 0.266 head diameter)	6	4
50	24/0	3/8	6d box (2 x 0.099 x 0.266 head diameter)	4	4
			8d common (2½ x 0.131 x 0.281 head diameter)	6	6
60	24/0	3/8	6d box (2 x 0.099 x 0.266 head diameter)	4	3
			8d common (2½ x 0.131 x 0.281 head diameter)	6	4
70	24/16	7/16	8d common (2½ x 0.131 x 0.281 head diameter)	4	4
			10d box (3 x 0.128 x 0.312 head diameter)	6	4
80	24/16	7/16	8d common (2½ x 0.131 x 0.281 head diameter)	4	4
			10d box (3 x 0.128 x 0.312 head diameter)	6	4
90	32/16	15/32	8d common (2½ x 0.131 x 0.281 head diameter)	4	3
			10d box (3 x 0.128 x 0.312 head diameter)	6	4

95

R802 Wood Roof Framing

- Revised provisions clarify ridge beam and ceiling joist requirements.

96

Table R802.5.2(1) Rafter/Ceiling Joist Heel Joint Connections

RAFTER SLOPE	RAFTER SPACING (inches)	GROUND SNOW LOAD (psf)											
		20[e]			30			50			70		
		Roof span (feet)											
		12	24	36	12	24	36	12	24	36	12	24	36
		Required number of 16d common nails per heel joint splice[a,b,c,d,f]											
3:12	12	3	5	8	3	6	9	5	9	13	6	12	17
	16	4	7	10	4	8	12	6	12	17	8	15	23
	19.2	4	8	12	5	10	14	7	14	21	9	18	27
	24	5	10	15	6	12	18	9	17	26	12	23	34
4:12	12	3	4	6	3	5	7	4	7	10	5	9	13
	16	3	5	8	3	6	9	5	9	13	6	12	17
	19.2	3	6	9	4	7	11	6	11	16	7	14	21
	24	4	8	11	5	9	13	7	13	19	9	17	26
5:12	12	3	3	5	3	4	6	3	6	8	4	7	11
	16	3	4	6	3	5	7	4	7	11	5	9	14
	19.2	3	5	7	3	6	9	5	9	13	6	11	17
	24	3	6	9	4	7	11	6	11	16	7	14	21
⋮													
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	24	3	3	4	3	3	5	3	5	7	3	6	9

97

R905.4.4.1 Metal Roof Shingle Wind Resistance

- Requirements for metal shingle wind resistance are added to Section R905.4.

98

Table R905.4.4.1 Classification of Steep Slope Metal Roof Shingles Tested per ASTM D3161

MAXIMUM ULTIMATE DESIGN WIND SPEED, V_{ULT} FROM FIGURE R301.2(5)A (mph)	MAXIMUM BASIC WIND SPEED, V_{ASD} FROM TABLE R301.2.1.3 (mph)	ASTM D3161 SHINGLE CLASSIFICATION
110	85	A, D or F
116	90	A, D or F
129	100	A, D or F
142	110	F
155	120	F
168	130	F
181	140	F
194	150	F

99

Questions?

100

ICC SPRING INTERCHANGE

2021 International Fire Code

101

320 Additive Manufacturing

- Additive manufacturing is a process of joining materials to make objects from 3D model data, usually layer upon layer
- Two types of additive manufacturing:
  - Industrial additive manufacturing
  - Non-industrial additive manufacturing

102

320 Additive Manufacturing

- *Industrial* additive manufacturing utilizes combustible powders or metals, an inert gas supply, a combustible dust collection system, or creates a hazardous (classified) location area or zone outside of the equipment
- *Industrial* additive manufacturing requirements:
  - Operational permit
  - Listed to UL 2011
  - Use of inert gases must comply with Ch 53
  - FCO can require technical assistance and require an evaluation report
  - Only allowed in manufacturing facilities
  - If the quantities of hazardous materials exceed the maximum allowable quantity per control area, the room or building will become a Group H

103

320 Additive Manufacturing

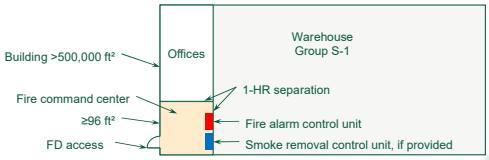
- *Non-industrial* additive manufacturing
  - 3D printing operations that do ***not*** create a hazardous (classified) location area outside of the equipment, and do ***not*** utilize an inert gas supply or a combustible dust collection system
- Must be listed

- Self-contained unit
- ≤30 L of production material
- Cannot use inert gas or combustible dust

104

508 Fire Command Center

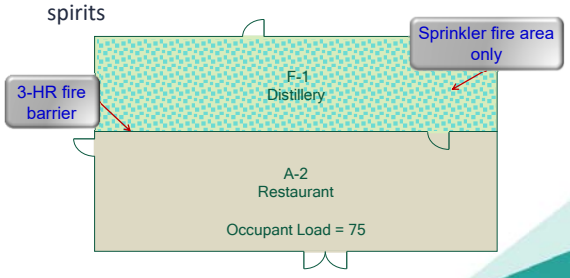
- Fire command center now required in Group F-1 and S-1 where the building footprint > 500,000 sf
- Fire command center must be a minimum of 96 sf with the smallest dimension of 8'



105

903.2.4.2 Distilled Spirits

- Sprinkler system is required throughout the fire area of Group F-1 used for manufacture of distilled spirits



106

903.2.4.2 Distilled Spirits

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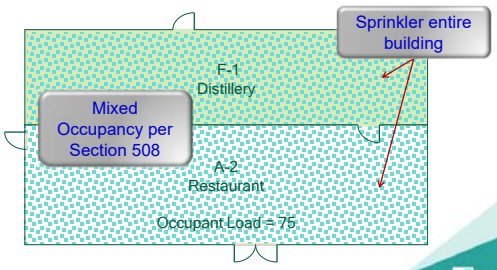


107

903.2.9.3 Distilled Spirits

- Sprinkler system is required throughout the fire area of Group S-1 used for bulk storage of distilled spirits or wine

Wine storage with alcohol content of ≤ 16% would be classified as Group S-2

108

903.2.10 Group S-2 Parking Garage

- Open parking garages now have threshold for the installation of a sprinkler system
  - Open parking garage with a fire area > 48,000 sf

109

903.3.1.2 NFPA 13R Sprinkler Systems

- NFPA 13R sprinkler design allowed ***IF***

4 stories above grade plane

No longer count floors above pedestal

Floor level ≤30' above LLFDVA

Floor level ≤30' below LLFDVA

110

907.2.10 Public-storage and Self-storage Facilities

- Manual fire alarm system required in Group S public- and self-storage facilities ≥ 3 stories
- Coverage of interior corridors and interior common areas

Only 1 manual fire alarm box required ***IF*** building is sprinklered

Visible notification ***not*** required in storage units

111

907.5.2.1.2 Audible Alarm Sound Pressure

- The threshold for elimination of audible notification appliances has increased from 95 dBA to 105 dBA
- Where the ambient noise level >105 dBA, audible devices are not required

112

907.5.2.1.3 Low-frequency Alarms

- Sleeping rooms in Group R-1 and R-2 shall be provided with a notification signal with a 520 Hz low-frequency signal
- This alarm signal frequency is more effective in waking children and adults over 65 or alcohol impaired

Low-frequency signals can be provided by the alarm itself, or by mounting the alarm on a sounder base

Photo courtesy of Daniel P. Finnegan, Siemens Industry, Inc.

113

907.5.2.3.3.1 Expansion Capability in Group R-2 Occupancies

- Fire alarm systems in Group R-2 shall be designed for future visible notification by one of the following:
  - Replacement of audible appliances with audible/visible appliances, or
  - Extension of existing wiring from the unit smoke alarm locations to visible appliances, or
  - Fire alarm power supply and circuits shall provide ≥ 5% excess capacity with a single access point to such circuits shall be available on every story

114

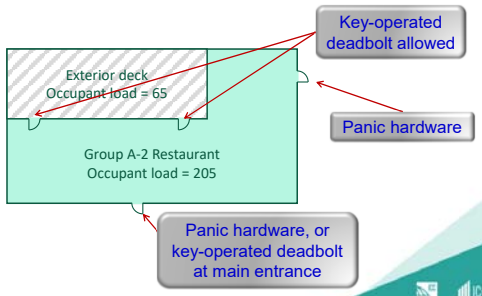
1008.2.1 Stairway Illumination

- Exit stairways, exit access stairways and their associated landings must now have an illumination level under normal power of at least 10 footcandles.
  - Measured at the walking surface
  - Not applicable to stairs in exit discharge
  - Required only when stairway is in use, allowing for occupant-sensor or daylight-responsive controls
  - Exceptions for auditoriums, theaters and similar assembly occupancies still applicable
- Considered as an easily accomplished means for improving stairway safety

115

1010.2.4 Locks and Latches

- Except in egress courts, where the egress path travels back into the building, key-operated deadbolts are allowed to be used as the locking device



116

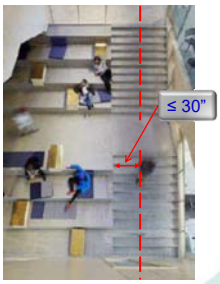
1010.2.4 Locks and Latches

- Occupant load ≤300 and sign posted
- Weatherproof telephone or 2-way communication system adjacent 1 door on the exterior side
- Locking device is readily distinguishable as locked
- Locking device shall be key-operated
- Clear window or glazed door opening, ≥5 ft² at each exit access
- Sign on the interior side at each locked: THIS DOOR TO REMAIN UNLOCKED WHEN THE OUTDOOR AREA IS OCCUPIED

117

1030.16 Handrails at Social Stairs

- Where seating occurs on one side of stairs and stairs are < 74" wide, only 1 handrail is required
- Where seating occurs on one side of stairs and stairs are ≥ 74" wide, 2 handrails are required
  - Handrail must be ≤ 30" of the tiered floor



118

1030.16 Handrails at Social Stairs

- Handrail on the seating side shall be discontinuous
- Where seating is on both sides of stairs, mid-aisle handrail shall be discontinuous

119

1103.5.4 Sprinklers in High-rise

- Sprinklers required in existing high-rise ***IF*** any of the following exist:
  - Occupied floor > 75' and ≤ 120' and building does not have ≥ 2 interior exit stairs complying with Section 1104.10 with 2-hour enclosure

Section 1104.10
- Tread rise ≤ 8¼"
- Tread run ≥ 9"

This section only applies ***IF*** Appendix M is ***NOT*** adopted

120

1103.5.4 Sprinklers in High-rise

- Sprinklers required in existing high-rise ***IF*** any of the following exist:
  - Occupied floor > 75' and ≤ 120' and building does not have a fire alarm system with smoke detection in:
    - Electrical, mechanical, transformer, telephone rooms
    - Corridors
    - Elevator lobbies
    - Doors penetrating interior exit stairway enclosures

This section only applies ***IF*** Appendix M is ***NOT*** adopted

121

1103.5.4 Sprinklers in High-rise

- Sprinklers required in existing high-rise ***IF*** any of the following exist:
  - Occupied floor >120' above LLFDVA

Where any of the 3 conditions exist, the owner must:
- File a compliance schedule within 1 year of notification
- Complete the sprinkler installation within 12 years

This section only applies ***IF*** Appendix M is ***NOT*** adopted

122

1103.7.5.1 Fire Alarm in Group R-1 Hotel/Motel

- Manual fire alarm system required in existing R-1 hotel or motel when >1 story or >20 sleeping rooms, except:
  1. Fire alarm system not required if only 1-story with >20 sleeping rooms ***AND*** each room has direct access to public way ***AND*** each sleeping room is separated by 1-HR
  2. Fire alarm system not required if ≤3 stories with ≤20 sleeping rooms ***AND*** is sprinklered with NFPA 13 or 13R
  3. Fire alarm system is required but only 1 manual fire alarm box ***IF*** sprinklered with NFPA 13 or 13R

123

1103.9 CO Detection in Existing Buildings

- CO detection required in existing:
  - Group I-1, I-2, I-4
  - Group R
  - Classrooms in Group E
- Can be battery operated CO alarms if the code in effect at the time of construction did not require CO detection
- Can be CO alarms or CO detection system

124

1203.1.2 Fuel Piping Protection

- Fuel piping for emergency and standby generators requires fire-resistance-rated protection
  - 2-HR listed pipe-protection system – UL 1489
    - Reduced to 1-HR if sprinklered with NFPA 13
  - An assembly provided 2-HR fire-resistance rating
    - Reduced to 1-HR if sprinklered with NFPA 13
  - Other approved methods

Photo courtesy of 3M

125

1204 Portable Generators

- Portable generators manufactured after 1/1/2021 must be listed to UL 2201
- Must be grounded
- Portable generators operated:
  - Only outdoors or enclosed areas
  - ≥ 5' from building openings or air intakes
  - Separation from tents per Chapter 31
- Temporary wiring shall be provided with GFCI

Grounding rod

Do not refuel while the generator is operating

126

1204 Portable Generators

- Connections to premise wiring system shall ***NOT*** be provided by back-feeding through receptacles
- Connection to a premise served by commercial power must be through a transfer switch
- Connections to buildings not served by commercial power shall comply with NFPA 70

If no transfer switch is available, then the use of relocatable power taps and extension cords to power appliances must comply with §603

127

1207 Electrical Energy Storage Systems

- Entire content of Sesction 1207 has been revised
  - Nickel metal hydride technology now included
  - "Other battery technologies" is listed along with "other electrochemical ESS technologies"
  - Sodium batteries are no longer listed separately
    - Included under "Other electrochemical ESS technologies" and are regulated at 3 kWh
  - Capacitor ESS systems included
    - Regulated at ≥3 kWh

Photo provided by Getty Images with permission

128

2404.3.3.6 Size of Spray Booths

- Individual spray booths are no longer limited to 1,500 sf
- Limited to the smaller of:
  - 10% of the floor area of the building
  - Basic allowable area for Group H-2
- When only a single booth, it can be 500 sf
  - Even when it exceeds 10%

129

2404.3.3.6 Size of Spray Booths

- IBC Table 506.2

Basic allowable area

Occupancy Classification	See Footnotes	TYPE I		TYPE II	
		A	B	A	B
F-1	NS	UL	UL	25,000	15,500
	S1	UL	UL	100,000	62,000
	SM	UL	UL	75,000	46,500

EXAMPLE

Group F-1
Type IIB construction
1-story
Sprinklered
50,000 sf

10% of floor area → Spray Booth 5,000 sf

130

Table 3203.8 Lithium-ion Batteries

- Listed as high-hazard commodity
- Can be classified as high-piled storage > 6'

Product Category	Product	Classification
Batteries	Dry cells (excludes lithium, lithium-ion and other similar exotic metals or combustible electrolyte); without blister packing (if blister packed, refer to the commodity classification definitions)	Class I
	Dry cells (nonlithium or similar exotic metals); in blister packing; cartoned	Class II
	Vehicle; any size (for example, automobile or truck); empty plastic casing	High-hazard (Group A unexpanded)
	Vehicle; large (in other words, truck or larger); dry or wet cells (excludes lithium-ion and other cells containing combustible electrolytes)	High-hazard (Group A unexpanded)
	Vehicle; small (for example, automobile); wet cells (excludes lithium-ion and other cells containing combustible electrolytes)	Class I
	Lithium-ion	High-hazard

131

3209.4 Automatic Rack Storage Shutdown

- Automated rack storage systems are required to be provided with shutdown ***IF*** high-piled storage area > 500 sf
  - Manual shutdown switch
  - Automatic shutdown activated by either of the following:
    - Sprinkler water flow
    - Activation of fire detection system

132

3305.5 Fire Watch – Demolition

- Fire safety plan is required
- Fire watch provided for demolition ***IF***:
  - Required by fire safety plan, or
  - Required by FCO

133

3305.5.1 Fire Watch – New Construction

- Fire safety plan is required
- Fire watch provided for new construction ***IF***:
  - > 40' above lowest adjacent grade,
  - New multi-story construction > 50,000 sf per story,
  - Required by fire safety plan, or
  - Required by FCO

134

3305.5.1 Fire Watch

- ***IF*** fire watch is required, it must be provided:
  - During nonworking hours
  - When construction >40' above lowest adjacent grade
- Fire watch personnel
  - Must be trained
  - Keep written log
- Fire watch for hot work is still required

This fire watch is different than fire watch for hot work

135

Chapter 40 Distilled Spirits and Wines

- New chapter for storage of distilled spirits and wines
- Not classified as Group H
  - Group F-1 and S-1 for beverages > 16% alcohol content
  - Group F-2 and S-2 for beverages ≤ 16% alcohol content
- Chapters 50 and 57 do not apply to storage when in compliance with Chapter 40

136

4003 Distilled Spirits and Wines

- Protection of storage areas
  - Spill control
    - 2nd containment not required
  - Ventilation
    - 1 cfm/ft², ***OR***
    - Monitored and ventilated to maintain ≤25% LFL
  - Control of ignition sources
    - No smoking
    - Listed equipment for hazardous (classified) areas
  - Lightning protection

137

4004, 4005 Storage

- Fire sprinklers required if stored in basement and:
  - Class I cannot exceed MAQ for open-use systems
  - Class II or IIIA are not limited
- Fire sprinklers
  - Sprinklers required throughout Group F-1 fire areas used for manufacture of distilled spirits
  - Sprinklers required throughout Group S-1 fire areas used for bulk storage of distilled spirits or wine

138

5001.1 Haz Mat Exceptions

- Correlation of Chapter 50 exceptions with other portions of the code
  - Flammable liquids in motor fuel-dispensing facilities – Chapter 23
  - Fuel oil in tanks and containers connected to oil-burning equipment – Section 603
  - Aerosol products – Chapter 51
  - Flammable or combustible liquids with a flash point > 95°F in a water-miscible solution – Chapter 57
  - Commercial cooking oil storage tank – Section 607

139

5001.1, Exc. 10 Beer, Distilled Spirits and Wine

- Storage of beer, distilled spirits and wine is not classified as a hazardous material
- Exception 10 is revised to:
  - Add beer to the list of distilled spirits and wine
  - Remove the specification of wooden barrels

- Note this exception is only for storage
- It does exempt brewing, distilling or processing

140

5001.1, Exc. 15 Flammable/Combustible Liquids

- Definitions of flammable liquid and combustible liquid have been revised
  - If flash point but no fire point, then it is not classified as a flammable or combustible liquid
- Consistent with Section 5701.2 Exception 7
  - Exception 15 added to Section 5001.1 to match Chapter 57
  - But if material has other haz mat characteristics, those classifications must be addressed

Flash Point is the minimum temperature at which a liquid will give off sufficient vapors to form anitan igble mixture with air near the surface or in the container, but will not sustain combustion.

Fire Point is the lowest temperature at which a liquid will ignite and achieve sustained burning when exposed to a test flame.

141

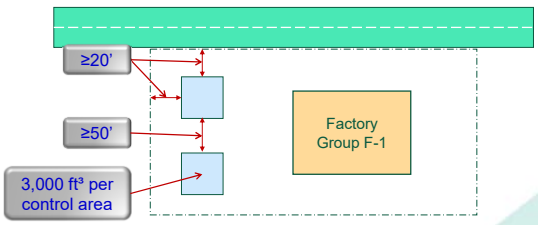
5003.12 Outdoor Control Areas

- Section 5003.12 is specified as "general requirements"
- Sections 5004.14, 5005.3.3 and 5005.4.3 have been revised to state outdoor storage must comply with outdoor control area requirements, except where material specific requirements are found in the code or referenced standard

142

5003.12 Outdoor Control Areas

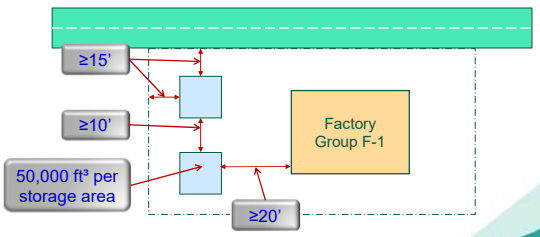
- Outdoor control area for flammable gas



143

5003.12 Outdoor Control Areas

- Outdoor control area for gaseous H_2 – NFPA 2



144

5601.1.3 Consumer Use Fireworks

- Where allowed, the storage, use and handling of Division 1.4G fireworks shall comply with 2006 NFPA 1124
  - Display height ≤ 6'
  - Display height along wall ≤ 12'
  - Vertical flame breaks provided every 16' horizontally
  - ≥ 50% of floor area shall be aisles

Flame breaks constructed of:
- Sheet steel
- Sheet aluminum ≥0.010" thick
- Hardboard ≥1/8" thick
- Gypsum board ≥3/8" thick
- Wood panels ≥1/8" thick
- Plywood ≥1/4" thick
- Particleboard ≥1/4" thick
- Cement fiberboard
- Plastic laminate ≥1/8" thick
- Safety glass ≥1/8" thick
- Other approved material

145

NFPA 1124 Consumer Use Fireworks

- Dead-end aisles are prohibited
- Exit access travel distance ≤ 75 feet
- Sprinklers required if new building > 6,000 sf
- Sprinklers required if existing building > 7,500 sf
- Smoke/heat vents required in new permanent buildings with ceiling height < 10' and exit access travel distance > 25'
- Temporary stands > 800 sf must meet all requirements of a permanent structure

146

Questions?

147

Thank you for Attending

Visit learn.iccsafe.org for more training opportunities

148

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This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

149

Accreditation

- The International Code Council has been accredited as an Authorized Provider by the International Association for Continuing Education and Training (IACET).
  - As a result of their Authorized Provider accreditation status, ICC is authorized to offer IACET CEUs for its programs that qualify under the ANSI/IACET Standard.
- You will obtain full CEUs for this course, if you actively participate in the training activities and stay for the entire session. Evidence of this will be the sign out sheet.

150

Copyright Materials

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151

ICC SPRING INTERCHANGE

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152

File Attachments for Item:

EC-6 2021 IECC Update (ICC)

All certifications (2 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 IECC Update

Course instructor: Jerica Stacey

Course description: This session reviews key changes from the 2018 to the 2021 edition of the International Energy Conservation Code® (IECC®). The discussion will address changes to both the residential and commercial provisions of the IECC. The seminar will assist code officials, plans examiners, inspectors, and design professionals in identifying the specific code changes that have occurred and understanding the reasoning behind the changes.

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: May 1, 2023 / Tampa Bay, FL

Special Content:

Code Administration:_____

Existing Buildings: _____

Electrical Instruction: _____

Plumbing Instruction:_____

Conference Course: 2021 IECC Update

Conference Name: ICC Spring Interchange

Conference location: Tampa Bay, FL

Course to be offered online? N/A **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Significant Changes to the 2021 International Energy Conservation Code

Length: 2-hour course

Residential and Commercial

Description

This seminar will assist participants in implementing the transition from the *2018 International Energy Conversation Code*® (IECC®) to the 2021 edition. This course will focus on the key changes and their effects on design, review and inspection requirements.

Course Objectives

At the end of this presentation, attendees will be able to:

- Identify the importance of the energy code in reducing building energy use and providing other environmental benefits
- Explain the intent, scope and applicability of the 2021 IECC requirements for commercial and residential building projects
- Identify the most significant administrative changes to the 2021 IECC and changes that increase the useability of the code
- Identify the most significant energy efficiency changes in the 2021 IECC and potential impact on the design, plan review and inspection communities

Timed Outline

Length	Topic
10 minutes	Course and instructor introductions Overview of the IECC and energy efficiency improvements
10 minutes	Residential and Commercial Administrative changes (Chapter 1 and 2) and General changes (Chapter 3)
10 minutes	Commercial intro and general changes (Chapter 4, Section 401)
10 minutes	Commercial building envelope (Chapter 4, Section 402)
10 minutes	Commercial mechanical systems, service hot water (Chapter 4, Sections 403 and 404)
10 minutes	Commercial electrical power and lighting systems (Chapter 4, Section 405); Commercial additional efficiency requirements (Chapter 4, Section 407)
10 minutes	Commercial total building performance and commissioning, existing buildings, appendices (Chapter 4, Sections 407 and 408)
10 minutes	Residential intro and general changes (Chapter 4, section 401) Residential building envelope (Chapter 4, Section 402)
10 minutes	Residential systems (Chapter 4, Section 403)
10 minutes	Residential electrical power and lighting systems (Chapter 4, Section 404)
10 minutes	Residential additional efficiency package options (Chapter 4, Section 408); Residential existing buildings and appendices (Chapter 5; Appendices)
10 minutes	Code Council and partner resources Questions and closing

Jerica Stacey is an Energy Code Specialist with the International Code Council's Business and Product Development Group. Within this position, she supports the Code Council's energy code initiatives and energy codes and standards technical content development as well as advances the Code Council's business interests related to energy codes and standards for both the national and international markets. Jerica has 10 years of experience in the development, adoption and implementation of building energy codes.

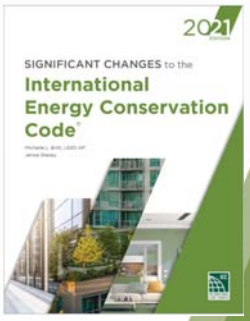
2021 IECC® Significant Changes

Based on the 2021 International Energy Conservation Code® (IECC®)

1

Course Description

- This seminar covers the significant changes within the *2021 International Energy Conservation Code® (IECC®)*



2

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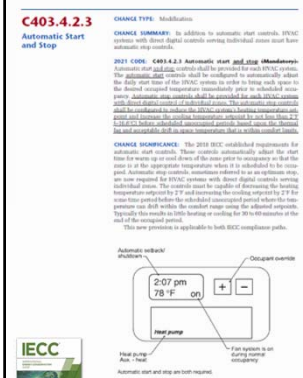
3

Useful Publications

Available on shop.iccsafe.org

4



Selection of Topics

Provisions addressed based primarily on:

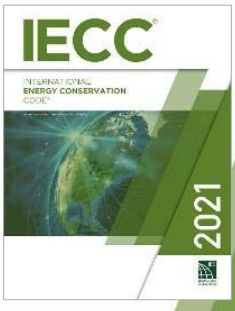
- Frequency of application
- Special significance
- Change in application

5

About the IECC

- The IECC regulates the design and construction of buildings for the effective use and conservation of energy over the useful life of each building.
- This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this objective.
- This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

C/R101.3



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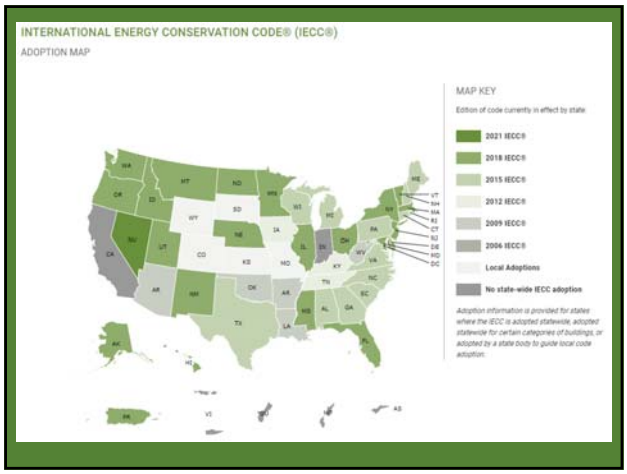

INTERNATIONAL ENERGY CONSERVATION CODE® (IECC®)
ADOPTION MAP
MAP KEY
Edition of code currently in effect by state
2021 IECC®
2018 IECC®
2015 IECC®
2012 IECC®
2009 IECC®
2006 IECC®
Local Adoptions
No state-wide IECC adoption

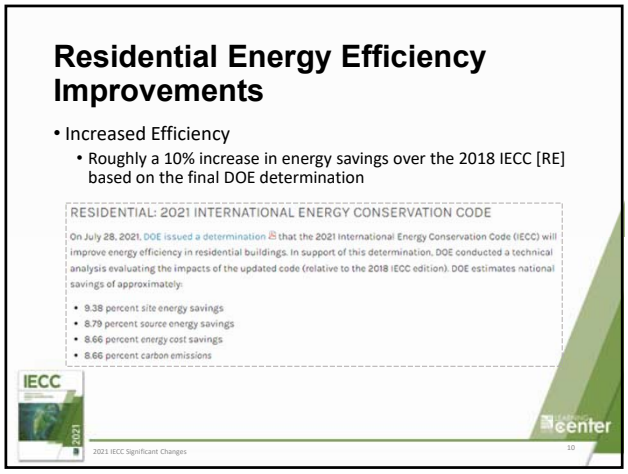
7


Commercial & Residential Buildings Defined
Residential: For this code, includes detached one- and two-family dwellings and townhouses as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane
Commercial: For this code, all buildings that are not included in the definition of "Residential building."
IECC
2021
2021 IECC Significant Changes
8

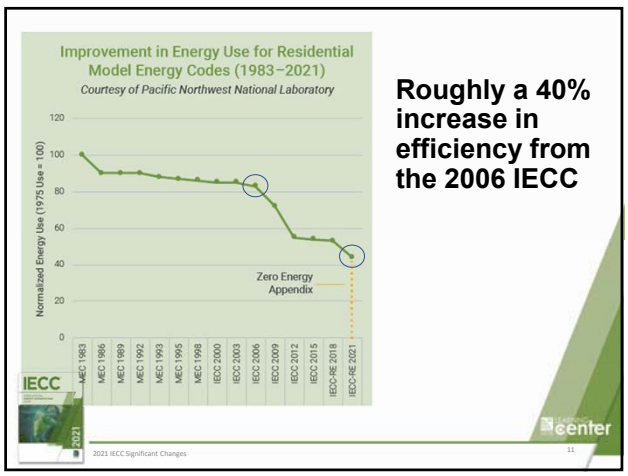
8


Increases in Efficiency—2021 IECC
IECC
2021

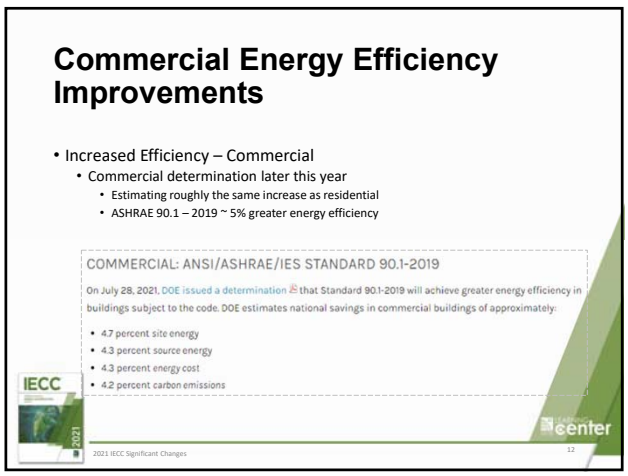
9


Residential Energy Efficiency Improvements
• Increased Efficiency
• Roughly a 10% increase in energy savings over the 2018 IECC [RE] based on the final DOE determination
RESIDENTIAL: 2021 INTERNATIONAL ENERGY CONSERVATION CODE
On July 28, 2021, DOE issued a determination that the 2021 International Energy Conservation Code (IECC) will improve energy efficiency in residential buildings. In support of this determination, DOE conducted a technical analysis evaluating the impacts of the updated code (relative to the 2018 IECC edition). DOE estimates national savings of approximately:
• 9.38 percent site energy savings
• 8.79 percent source energy savings
• 8.66 percent energy cost savings
• 8.66 percent carbon emissions
IECC
2021
2021 IECC Significant Changes
10

10


Improvement in Energy Use for Residential Model Energy Codes (1983–2021)
Courtesy of Pacific Northwest National Laboratory
Normalized Energy Use (1975 Use = 100)
120
100
80
60
40
20
0
Zero Energy Appendix
MEC 1983
MEC 1986
MEC 1989
MEC 1992
MEC 1993
MEC 1995
MEC 1998
IECC 2000
IECC 2003
IECC 2006
IECC 2009
IECC 2012
IECC 2015
IECC-RE 2018
IECC-RE 2021
Roughly a 40% increase in efficiency from the 2006 IECC
IECC
2021
2021 IECC Significant Changes
11

11


Commercial Energy Efficiency Improvements
• Increased Efficiency – Commercial
• Commercial determination later this year
• Estimating roughly the same increase as residential
• ASHRAE 90.1 – 2019 ~ 5% greater energy efficiency
COMMERCIAL: ANSI/ASHRAE/IES STANDARD 90.1-2019
On July 28, 2021, DOE issued a determination that Standard 90.1-2019 will achieve greater energy efficiency in buildings subject to the code. DOE estimates national savings in commercial buildings of approximately:
• 4.7 percent site energy
• 4.3 percent source energy
• 4.3 percent energy cost
• 4.2 percent carbon emissions
IECC
2021
2021 IECC Significant Changes
12

12

Administrative and General Changes

Commercial and Residential Chapters 1 through 3

13

Alignment with Other I-Codes

- Proposals by BCAC were introduced to better align Chapter 1 with the other I-Codes

Commercial

- Within C102 Alternative Materials, C106 Notice of Approval, C109 Stop Work Order

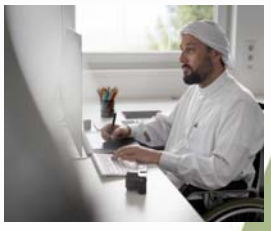
Residential

- Within R102 Alternative Materials, R106 Notice of Approval, R109 Stop Work Order, and R110 Means of Appeals

14

Digital Construction Documents

- Construction documents may be submitted in a digital format



C/R103.1

15

Information on Construction Documents

- Information required on the construction documents has been expanded to include an indication of the energy compliance path used
- Clarifies requirements for air barrier and air sealing details and locations

C/R103.2

16

Information on Construction Documents Continued

1. Energy compliance path.
2. Insulation materials and their *R*-values.
3. Fenestration *U*-factors and solar heat gain coefficients (SHGCs).
4. Area-weighted *U*-factor and solar heat gain coefficient (SHGC) calculations.
5. Mechanical system design criteria.
6. Mechanical and service water-heating systems and equipment types, sizes and efficiencies.
7. Economizer description.
8. Equipment and system controls.
9. Fan motor horsepower (hp) and controls.
10. Duct sealing, duct and pipe insulation and location.
11. Lighting fixture schedule with wattage and control narrative.
12. Location of daylight zones on floor plans.
13. Air ~~sealing details~~ barrier and air sealing details, including the location of the air barrier.

C103.2

17

Other New or Revised Definitions

- Commercial New
  - Biogas
  - Biomass
  - Data center, Data center systems
  - Direct Digital Control (DDC)
  - Enthalpy recovery ratio
  - Fault detection and diagnostics (FDD) system
  - Information technology equipment
  - Internal curtain system
  - Large diameter ceiling fan
  - Testing unit enclosure area
  - Thermal distribution efficiency (TDE)
  - Vegetative roofs
  - Visible transmittable, annual
- Commercial Revised
  - General lighting
  - Green houses
  - On-site renewable energy
  - Skylights
  - Wall, above-grade
- Residential New
  - Access (to)
  - Cavity insulation
  - Dimmer
  - Dwelling unit enclosure area
  - Occupant sensor control
  - On-site renewable energy
  - Ready access (to)
  - Renewable energy certificate (REC)
  - Renewable energy sources
  - Thermal distribution efficiency (TDE)
- Residential Revised
  - Demand Recirculation Water System
  - Skylights
  - High-efficacy light sources
  - Roof recover

C/R202

18

On-site Renewable Energy and Renewable Energy Resources

- **ON-SITE RENEWABLE ENERGY.** Energy ~~derived~~ from renewable energy resources harvested at the building project site. ~~solar radiation, wind, waves, tides, landfill gas, biogas, biomass or the internal heat of the earth. The energy system providing onsite renewable energy shall be located on the project site.~~
- **RENEWABLE ENERGY RESOURCES.** Energy derived from solar radiation, wind, waves, tides, landfill gas, biogas, biomass or extracted from hot fluid or steam heated within the earth.

C202

2021 IECC Significant Changes 19

19

Fan Efficiencies

New definitions related to fans introduce and support the Fan Energy Index

- **FAN ENERGY INDEX (FEI).** The ratio of the electric input power of a reference fan to the electric input power of the actual fan as calculated in accordance with AMCA 208.
- **FAN, EMBEDDED.** A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.
- **FAN ARRAY.** Multiple fans in parallel between two plenum sections in an air distribution system.
- **FAN NAMEPLATE ELECTRICAL INPUT POWER.** The nominal electrical input power rating stamped on a fan assembly nameplate.
- **FAN SYSTEM ELECTRICAL INPUT POWER.** The sum of the fan electrical power of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the conditioned spaces and/or return it to the source or exhaust it to the outdoors.

C202

2021 IECC Significant Changes 20

20

High-Efficacy Light Sources

HIGH-EFFICACY LIGHT SOURCES. Any lamp with an efficacy of not less than 65 lumens per watt, or luminaires with an efficacy of not less than 45 lumens per watt.

R202

2021 IECC Significant Changes 21

21

Renewable Energy Certificate

- **RENEWABLE ENERGY CERTIFICATE (REC).** An instrument that represents the environmental attributes of one megawatt hour of renewable energy; also known as an energy attribute certificate (EAC).

R202

2021 IECC Significant Changes 22

22

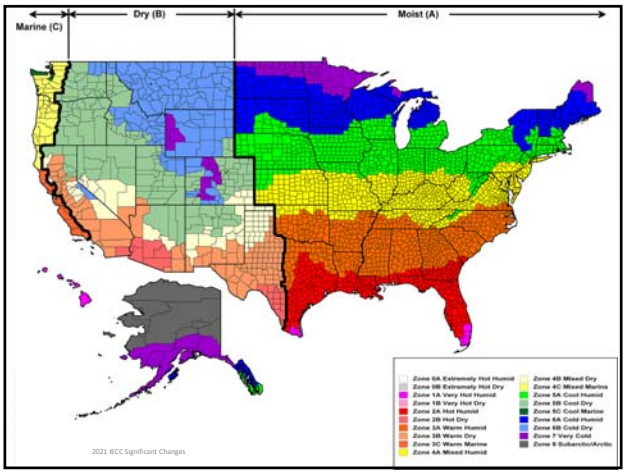
Climate Zone Definitions

Climate zones updated
- Align with ASHRAE 169, ASHRAE 90.1, IgCC
- New Climate Zone 0
- 10% of US counties assigned new CZ

C/R301.3

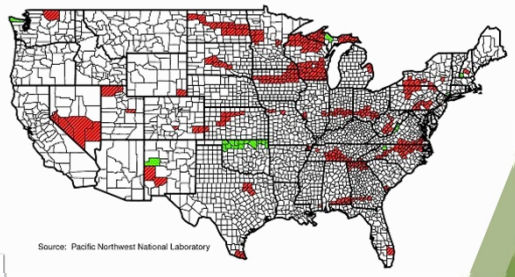
2021 IECC Significant Changes 23

23



24

County-Level Climate Zone Changes



Source: Pacific Northwest National Laboratory

C/R301.3

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Climate Zone Definitions Continued

TABLE R301.3(2) R301.3 Thermal Climate Zone Definitions

ZONE NUMBER	THERMAL CRITERIA IP Units	THERMAL CRITERIA SI Units
0	10,800 < CDD50°F	6000 < CDD10°C
1	9,000 < CDD50°F < 10,800	5000 < CDD10°C < 6000
2	6,300 < CDD50°F ≤ 9,000	3500 < CDD10°C ≤ 5000
~~3A and 3B~~ 3	~~4,500 <~~ CDD50°F ≤ 6,300 AND HDD65°F ≤ ~~5,400~~ 3,600	CDD10°C < 3500 AND HDD18°C ≤ ~~3000~~ 2000
~~4A and 4B~~ 4	CDD50°F < ~~4,500~~ 6,300 AND 3,600 < HDD65°F ≤ 5,400	CDD10°C < ~~3500~~ 3500 AND 2000 < HDD18°C ≤ 3000
~~3C~~	~~HDD65°F ≤ 3,600~~	~~HDD18°C ≤ 2000~~
~~4C~~	~~3,600 < HDD65°F ≤ 5,400~~	~~2000 < HDD18°C ≤ 3000~~
5	CDD50°F < 6,300 AND 5,400 < HDD65°F ≤ 7,200	CDD10°C < 3500 AND 3000 < HDD18°C ≤4000
6	7,200 < HDD65°F ≤ 9,000	4000 < HDD18°C ≤5000
7	9,000 < HDD65°F ≤ 12,600	5000 < HDD18°C ≤ 7000
8	12,600 < HDD65°F	7000 < HDD18°C

For SI: °C = [(°F) – 32]/1.8.

C/R301.3

26

Improved Useability

Mandatory and *Prescriptive* labels removed in favor of mandatory tables

- Total Building Performance
- Energy Rating Index

2018 IECC

C402.5 Air leakage—thermal envelope (Mandatory). The thermal envelope of buildings shall comply with Section C402.5.1 through C402.5.8, or the building thermal envelope shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft² (2.0 L/s • m²). Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

2021 IECC

C402.5 Air leakage—thermal envelope. The *building thermal envelope* shall comply with Sections C402.5.1 through Section C402.5.11.1, or the building *thermal envelope* shall be tested in accordance with Section C402.5.2 or C402.5.3. Where compliance is based on such testing, the building shall also comply with Sections C402.5.7, C402.5.8 and C402.5.9.

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Improved Useability

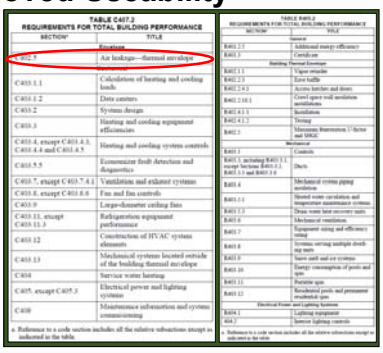

TABLE C407.2 REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION[a]	TITLE
	Equation
C402.5	Air leakage—thermal envelope
C403.1.1	Calculation of heating and cooling loads
C403.1.2	Data centers
C403.2	System design
C403.3	Heating and cooling equipment efficiencies
C403.4, except C403.4.3, C403.4.4 and C403.4.5	Heating and cooling system controls
C403.5.5	Economizer fault detection and diagnostics
C403.7, except C403.7.4.1	Ventilation and exhaust systems
C403.8, except C403.8.6	Fan and fan controls
C403.9	Large-diameter ceiling fans
C403.11, except C403.11.3	Refrigeration equipment performance
C403.12	Construction of HVAC system elements
C403.13	Mechanical systems located outside of the building thermal envelope
C404	Service water heating
C405, except C405.3	Electrical power and lighting systems
C408	Maintenance information and system commissioning

a. Reference to a code section includes all the relative subsections except as indicated in the table.

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Commercial Significant Changes

Chapter 4, Appendices

29

Compliance Path Options

- Compliance path options named and defined
  - Prescriptive Compliance
  - Total Building Performance
  - ASHRAE 90.1

C401.2 Application. Commercial buildings shall comply with Section C401.2.1 or C401.2.2.

C401.2.1 International Energy Conservation Code. Commercial buildings shall comply with one of the following:

1. Prescriptive Compliance. The Prescriptive Compliance option requires compliance with Sections C402 through C406 and Section C408. Dwelling units and sleeping units in Group R-2 buildings without systems serving multiple units shall be deemed to be in compliance with this chapter, provided that they comply with Section R406.
2. Total Building Performance. The Total Building Performance option requires compliance with Section C407.

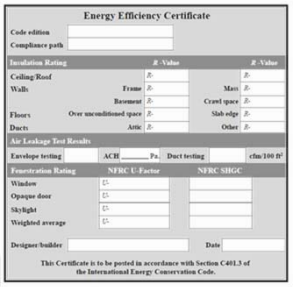
Exception: Additions, alterations, repairs and changes of occupancy to existing buildings complying with Chapter 5.

C401.2.2 ASHRAE 90.1. Commercial buildings shall comply with the requirements of ANSI/ASHRAE/IESNA 90.1.

C401.2

30

Envelope Certificate


Energy Efficiency Certificate

Code edition

Compliance path

Insulation Rating	R -Value		R -Value
Ceiling/Roof	R-		R-
Walls: Frame	R-	Mass	R-
Basement	R-	Crawl space	R-
Floors: Over unconditioned space	R-	Slab edge	R-
Ducts: Attic	R-	Other	R-

Air Leakage Test Results

Envelope testing: ACH ____ Pa. Duct testing: cfm/100 ft²

Fenestration Rating	NFRC U-Factor	NFRC SHGC
Window	U-	
Opaque door	U-	
Skylight	U-	
Weighted average	U-	

Designer/builder: Date

This Certificate is to be posted in accordance with Section C401.3 of the International Energy Conservation Code.

Sample thermal envelope certificate.

- Permanent thermal envelope certificate
  - R-values of insulation
  - U-factors and SHGCs of fenestration
  - Envelope air leakage test results
- Completed by approved party
- Posted in approved location and copy included in construction files for project

C401.3

31

Increased Efficiency: R-Value and U-Factor Overview

- Incremental increases in efficiency for many roof, wall and floor components in CZs 4-8
- R-13 insulation for framed floors in CZs 0 and 1
- R-10 CI for unheated slabs in CZ 3 Group R
- Non-swinging opaque doors moved from R-Value to U-Factor table

Changes align IECC with ASHRAE 90.1-2016 and 2019 requirements

Tables C402.1.3 and C402.1.4

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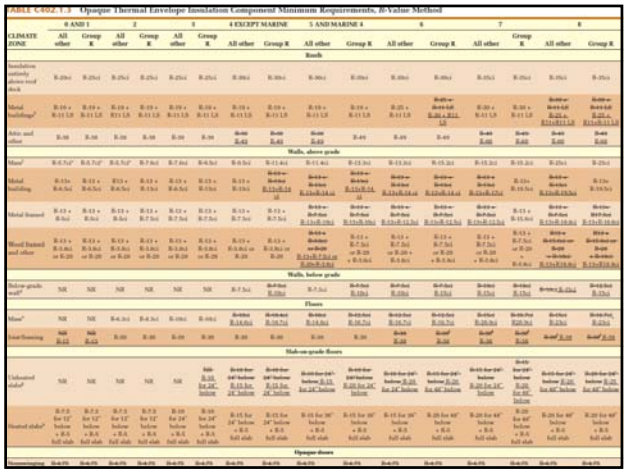
TABLE C402.1.3 Opaque Thermal Envelope Insulation Component Minimum Requirements, R-Value Method

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[a]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-30	R-30	R-30	R-30	R-30	R-30	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, above grade																
Mass[b]	R-6.7ci[c]	R-6.7ci[c]	R-6.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-20ci	R-25ci	R-25ci
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-16ci	R-13 + R-16ci + R-14.4ci	R-13 + R-16ci + R-14.4ci	R-13 + R-16ci + R-14.4ci	R-13 + R-16ci + R-14.4ci	R-13 + R-16ci + R-14.4ci	R-13 + R-16ci + R-14.4ci	R-13 + R-16ci + R-19.5ci	R-13 + R-16ci + R-19.5ci	R-13 + R-16ci + R-19.5ci
Metal framed	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci + R-13.5ci	R-13 + R-7.5ci + R-13.5ci	R-13 + R-7.5ci + R-13.5ci	R-13 + R-7.5ci + R-13.5ci	R-13 + R-7.5ci + R-13.5ci	R-13 + R-7.5ci + R-13.5ci	R-13 + R-7.5ci + R-19.5ci	R-13 + R-7.5ci + R-19.5ci	R-13 + R-7.5ci + R-19.5ci
Wood framed and other	R-13 + R-6.8ci or R-20	R-13 + R-6.8ci or R-20	R-13 + R-6.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-7.5ci	R-13 + R-7.5ci or R-20 + R-7.5ci	R-13 + R-7.5ci or R-20 + R-7.5ci	R-13 + R-7.5ci or R-20 + R-7.5ci	R-13 + R-7.5ci or R-20 + R-7.5ci	R-13 + R-7.5ci or R-20 + R-7.5ci	R-13 + R-7.5ci or R-20 + R-11.4ci	R-13 + R-7.5ci or R-20 + R-11.4ci	R-13 + R-7.5ci or R-20 + R-11.4ci
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-7.5ci	R-10ci	R-7.5ci	R-15ci	R-7.5ci	R-15ci
Floors																
Mass[e]	NR	NR	R-6.3ci	R-6.3ci	R-10ci	R-10ci	R-10ci	R-14.6ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci	R-20.9ci	R-20.9ci	R-20.9ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below
Heated slabs[f]	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab
Opaque doors																
Nonswinging door	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

33

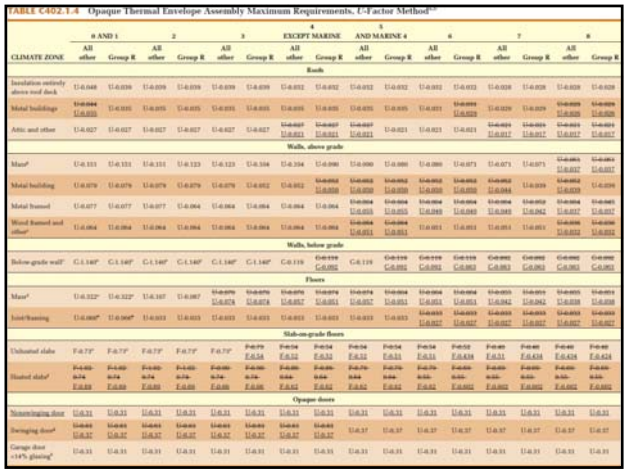
TABLE C402.1.4 Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.044 U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.029	U-0.029
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027 U-0.021	U-0.027 U-0.021	U-0.027 U-0.021	U-0.027 U-0.021	U-0.021	U-0.021	U-0.021	U-0.021 U-0.017	U-0.021 U-0.017	U-0.021 U-0.017
Walls, above grade																
Mass[a]	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.061 U-0.037	U-0.061 U-0.037
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052 U-0.050	U-0.052 U-0.050	U-0.052 U-0.050	U-0.052 U-0.050	U-0.052 U-0.050	U-0.052 U-0.044	U-0.039	U-0.052 U-0.039	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.055	U-0.055	U-0.049	U-0.049	U-0.049	U-0.042	U-0.037	U-0.037
Wood framed and other[a]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036 U-0.032	U-0.036 U-0.032
Walls, below grade																
Below-grade wall[b]	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-0.119	C-0.119	C-0.119 C-0.092	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass[a]	U-0.322[a]	U-0.322[a]	U-0.107	U-0.087	U-0.070 U-0.074	U-0.070 U-0.074	U-0.070 U-0.057	U-0.070 U-0.051	U-0.074 U-0.057	U-0.074 U-0.051	U-0.064 U-0.051	U-0.064 U-0.051	U-0.055 U-0.042	U-0.055 U-0.042	U-0.055 U-0.038	U-0.055 U-0.038
Joist/framing	U-0.066[a]	U-0.066[a]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033 U-0.027	U-0.033 U-0.027	U-0.033 U-0.027	U-0.033 U-0.027	U-0.033 U-0.027	U-0.033 U-0.027
Slab-on-grade floors																
Unheated slabs	F-0.73[a]	F-0.73[a]	F-0.73[a]	F-0.73[a]	F-0.73[a]	F-0.73 F-0.54	F-0.54 F-0.32	F-0.54 F-0.32	F-0.54 F-0.32	F-0.54 F-0.32	F-0.54 F-0.32	F-0.52 F-0.438	F-0.40 F-0.31	F-0.40 F-0.438	F-0.40 F-0.424	F-0.40 F-0.424
Heated slabs[d]	F-0.88	F-0.88	F-0.88	F-0.88	F-0.88	F-0.86 F-0.62	F-0.86 F-0.62	F-0.86 F-0.62	F-0.86 F-0.62	F-0.86 F-0.62	F-0.86 F-0.62	F-0.84 F-0.62	F-0.84 F-0.62	F-0.84 F-0.602	F-0.84 F-0.602	F-0.84 F-0.602
Opaque doors																
Nonswinging door	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door[b]	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door <14% glazing[c]	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

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Table C402.1.4 Footnotes

a. Where assembly U-factors, C-factors and F-factors are established in ANSI/ASHRAE/IES 90.1 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IES 90.1 Appendix A.

b. Where U-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table. The R-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the U-factor requirements for above-grade mass walls.

d. "Mass floors" shall be in accordance with Section C402.2.3.

e. These C-, F- and U-factors are based on assemblies that are not required to contain insulation.

~~f. The first value is for perimeter insulation and the second value is for full, under-slab insulation.~~

f. "Mass walls" shall be in accordance with Section C402.2.2.

g. Swinging door U-factors shall be determined in accordance with NFRC-100.

h. Garage doors having a single row of fenestration shall have an assembly U-factor less than or equal to 0.44 in Climate Zones 0 through 6 and less than or equal to 0.36 in Climate Zones 7 and 8, provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

Table C402.1.4

35

Fenestration U-Factor and SHGC Requirements Continued

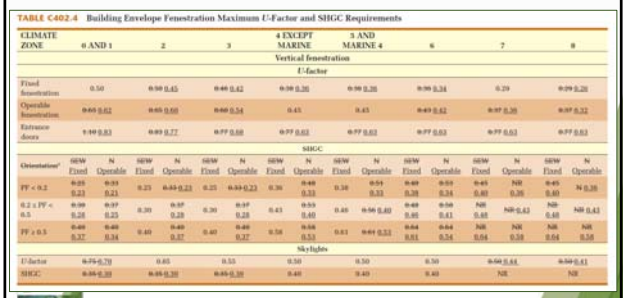
TABLE C402.4 Building Envelope Fenestration Maximum U-Factor and SHGC Requirements

CLIMATE ZONE	0 AND 1	2	3	4 EXCEPT MARINE	5 AND MARINE 4	6	7	8
Vertical fenestration								
U-factor								
Fixed fenestration	0.50	0.50 0.45	0.40 0.42	0.30 0.36	0.30 0.36	0.30 0.34	0.29	0.29 0.26
Operable fenestration	0.60 0.62	0.55 0.60	0.50 0.54	0.45	0.45	0.43 0.42	0.37 0.36	0.37 0.32
Entrance doors	1.10 0.83	0.83 0.77	0.77 0.68	0.77 0.63	0.77 0.63	0.77 0.63	0.77 0.63	0.77 0.63
SHGC								
Orientation[a]	NRW Fixed / Operable	N Fixed / Operable	NRW Fixed / Operable	N Fixed / Operable	NRW Fixed / Operable	N Fixed / Operable	NRW Fixed / Operable	N Fixed / Operable
PF < 0.2	0.25 0.23	0.31 0.23	0.33 0.23	0.25	0.33 0.23	0.36	0.40 0.33	0.36	0.51 0.33	0.40 0.38	0.51 0.34	0.45 0.40	NR 0.36	0.45 0.40	N 0.36
0.2 ≤ PF < 0.5	0.39 0.28	0.37 0.25	0.39	0.37 0.28	0.39	0.37 0.28	0.43	0.53 0.40	0.48	0.50 0.40	0.48 0.46	0.50 0.41	NR 0.43	0.48	NR 0.43
PF ≥ 0.5	0.40 0.37	0.40 0.34	0.40	0.40 0.37	0.40	0.38 0.37	0.58	0.58 0.53	0.83	0.83 0.53	0.64 0.61	0.64 0.54	NR 0.64	NR 0.58	NR 0.64	NR 0.58
Skylights								
U-factor	0.75 0.70	0.65	0.55	0.50	0.50	0.50	0.50 0.44	0.50 0.41
SHGC	0.35 0.30	0.35 0.30	0.35 0.30	0.40	0.40	0.40	NR	NR

Table C402.4

36

Air Leakage – Thermal Envelope Change Summary

- Dwelling unit testing required for Group R and Group I occupancies
- Building envelope testing required for occupancies other than Group R and I
- Buildings exempt from testing
  - Material or assembly
  - Performance verification

C402.5

2021 IECC Significant Changes 37

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Air Leakage

- **C402.5 Air leakage—thermal envelope.** The building thermal envelope shall comply with Sections C402.5.1 through Section C402.5.11.1, or the building thermal envelope shall be tested in accordance with Section C402.5.2 or C402.5.3. Where compliance is based on such testing, the building shall also comply with Sections C402.5.7, C402.5.8 and C402.5.9.
  - Air intakes, exhaust openings, stairways and shafts
  - Loading dock weather seals
  - Vestibules

This language picks up Section C402.5.1.2 Air barrier compliance
- Requires testing

C402.5

2021 IECC Significant Changes 38

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Air Barrier Testing – Group R and I

- Buildings with Group R and I occupancies must be tested using the **dwelling and sleeping unit enclosure testing** method
  - Required in all CZ except 2B, 3C and 5C
  - Adds new definition of testing unit enclosure area
  - Building thermal envelope must be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or an equivalent method
  - Air leakage limited to 0.30 cfm/ft² of testing unit enclosure area at 50 Pa

TESTING UNIT ENCLOSURE AREA. The area sum of all the boundary surfaces that define the *dwelling unit*, *sleeping unit* or occupiable *conditioned space* including top/ceiling, bottom/floor and all side walls. This does not include interior partition walls within the *dwelling unit*, *sleeping unit*, or occupiable *conditioned space*. Wall height shall be measured from the finished floor of the *conditioned space* to the finished floor or roof/ceiling air barrier above.

C402.5.1.2 and C402.5.2

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Air Barrier Testing – Group R and I Continued

- Where multiple dwelling/sleeping units or other occupiable conditioned spaces are contained within one building thermal envelope, each unit must be tested separately with an unguarded blower door test
  - The building air leakage is the weighted average of all testing unit results, weighted by each testing unit's enclosure area
  - 8 or less units, test them all
  - 8 or more units, test the greater of 7 units or 20 percent of all units
    - Top floor unit, ground floor unit, unit with largest area
    - For each unit that exceeds maximum air leakage rate (fails), test two more

C402.5.1.2 and C402.5.2

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40

Air Barrier Testing - All Other Occupancies

- Buildings or portions of buildings other than Group R and I occupancies must be tested using the **building thermal envelope testing** method
  - Tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158 or ASTM E1827 or an equivalent method
  - Air leakage limited to 0.40 cfm/ft² of building thermal envelope area at 75 Pa
  - Alternatively, portions of the building can be tested and measured air leakage area weighted
    - Entire envelope area of all stories that have any spaces directly under a roof
    - Entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade
    - Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space

C402.5.1.2 and C402.5.3

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Air Barrier Testing - All Other Occupancies Continued

- If the building air leakage rate exceeds 0.40 cfm/ft² but does not exceed 0.60 cfm/ft²
  - Diagnostic evaluation using smoke tracer or infrared imaging while building is pressurized required along with a visual inspection of the air barrier
    - Any leaks noted must be sealed where such sealing can be made without destruction of existing building components
    - A report identifying corrective actions taken to seal leaks must submitted to the code official and building owner
    - Building is deemed to comply, no retest required

Exceptions:

- Buildings in CZ 2B, 3B, 3C and 5C
- Buildings larger than 5,000ft² in CZ 0B, 1, 2A, 4B and 4C
- Buildings between 5,000ft² and 50,000ft² in CZs 0A, 3A and 5B

C402.5.1.2 and C402.5.3

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Buildings Exempt From Air Barrier Testing

Select Compliance Option
- Materials
- Assemblies

Verify Performance
- Review construction documents
- Inspect air barrier
- Final commission report provided
  - Deficiencies found during plan review and inspection and corrective actions

C402.5.1.2 and C402.5.1.5

43

Operable Openings Interlocking

- Large, operable openings (>40ft²) such as roll-up doors and windows must now be interlocked with the heating and cooling system
- Time and temperature specific
  - System adjustments within 10 minutes of opening operable opening
  - Controls raise cooling setpoint to 90°F and lower heating setpoint to 55°F
  - Controls shut off the system entirely when outdoor temperatures are below 90°F or above 55°F

C402.5.11 and C403.14

44

Fault Detection and Diagnostics

- HVAC systems serving a gross conditioned floor area of >100,000 ft² must include FDD system
- The system must include permanently installed sensors to measure HVAC system performance

Sample performance every 15 minutes → Identify and report faults → Provide recommendations for repair → Transmit recommendations to remotely located authorized personnel

Exception: R-1 and R-2 occupancies

C403.2.3

45

Equipment Performance Requirements

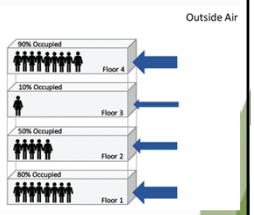
- Equipment must meet the minimum efficiency requirements of Tables C403.3.2(1) - (16)
  - HVAC equipment efficiency updated to match ASHRAE tables directly and Federal appliance manufacturing requirements
  - Additional tables added for
    - DOAS units
    - Water source heat pumps
    - Variable refrigerant flow cooling and heat pumps
    - Heat pump and heat reclaim chiller packages
    - Ceiling mounted computer room air conditioners
    - Commercial refrigerators and freezers
  - Refrigeration efficiencies updated to match federal requirements

C403.3.2, C403.11

46

Demand Control Ventilation

- Required for all single-zone systems required to comply with Sections C403.5 through C403.5.3
  - Economizers
- Required for spaces larger than 500 ft² and with an average occupant load of at 15 people or greater per 1,000 ft² of floor area
- Served by systems with
  - Air-side economizer
  - Automatic modulating control of the outdoor air damper
  - Design outdoor airflow greater than 3,000 cfm



Note several new/modified exceptions in 2021 IECC

C403.7.1

47

Fan Efficiency

- FEI Website: www.amca.org/fei
- Technical papers and educational resources about Fan Energy Index

Fan Energy Index (FEI) replaces Fan Efficiency Grade (FEG) metric

FEI ≥ 1.00 for covered fans

AMCA 208

Ratings from approved third-party lab and labeled

FEI includes effects (losses) of motors and drives, if sold with fan; otherwise, FEI ratings for bare fan include default motor/drive losses

Sizing / selection window eliminated
- "15 percentage points from peak total efficiency" was difficult to enforce

C403.8.3

48

Low-Capacity Ventilation Fans

- Requirements for low-capacity ventilation fans apply the efficiencies of ventilation fans typical of residential construction to mid-rise residential occupancies and small commercial buildings
  - Except when part of listed HVAC appliance
  - Except dryer exhaust, range hood main or booster fans

TABLE C403.8.5 Low-Capacity Ventilation Fan Efficacy*

FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIRFLOW RATE MAXIMUM (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
In-line fan	Any	3.8 cfm/watt	Any
Bathroom, utility room	10	2.8 cfm/watt	< 90
Bathroom, utility room	90	3.5 cfm/watt	Any

C403.8.5

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High Input Service Water-Heating Systems

- Large (over 1,000,000 Btu/h) service hot water system efficiency increases from 90% to 92%
- Capacity weighted average

Photo credit: PNNL

C404.2.1

2021 IECC Significant Changes 50

50

Occupant Sensor Controls in Warehouse Storage Areas

- Lighting in aisleway must be independent
- Time delay for occupants leaving the warehouse area and turning off or reducing the lighting is 20 minutes
- Occupancy sensor or time-switch control required

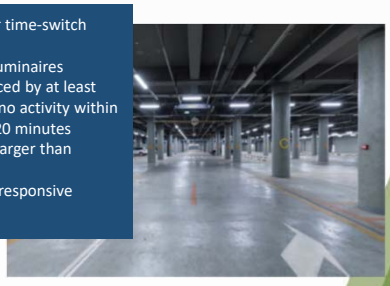
C405.2.1.2

2021 IECC Significant Changes 51

51

Parking Garage Lighting Control

- Occupant sensor or time-switch control required
- Lighting power of luminaires automatically reduced by at least 30% when there is no activity within a lighting zone for 20 minutes
- Lighting zones not larger than 3,600ft^2
- Perimeter daylight responsive controls



C405.2.8

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Lighting for Plant Growth

- At least 95% of permanently installed luminaires used for plant growth and maintenance must have a photon efficiency of not less than 1.6 µmol/J
- ANSI/ASABE S640

C405.4

2021 IECC Significant Changes 53

53

Automatic Receptacle Control

- At least 50% of covered receptacles and 25% of branch circuit feeders to be on automatically controlled receptacles
- Multiple control options
- All controlled receptacles must be permanently marked per NFPA 70

C405.11

2021 IECC Significant Changes 54

54

Energy Monitoring

- Applies to new buildings 25,000 ft² or larger
- Must be equipped to measure, monitor, record and report energy consumption data
- Exception: R-2 occupancies and individual tenant spaces if the space has its own utility services and meters and has less than 5,000 ft²

TABLE C405.12.2
ENERGY USE CATEGORIES

LOAD CATEGORY	DESCRIPTION OF ENERGY USE
Total HVAC system	Heating, cooling and ventilation, including but not limited to fans, pumps, boilers, chillers and water heating. Energy used by 120-volt equipment, or by 208/120-volt equipment that is located in a building where the main service is 480/277-volt power, is permitted to be excluded from total HVAC system energy use.
Interior lighting	Lighting systems located within the building.
Exterior lighting	Lighting systems located on the building site but not within the building.
Plug loads	Devices, appliances and equipment connected to convenience receptacle outlets.
Process load	Any single load that is not included in an HVAC, lighting or plug load category and that exceeds 5 percent of the peak connected load of the whole building, including but not limited to data centers, manufacturing equipment and commercial kitchens.
Building operations and other miscellaneous loads	The remaining loads not included elsewhere in this table, including but not limited to vertical transportation systems, automatic doors, motorized shading systems, ornamental fountains, ornamental fireplaces, swimming pools, in-ground spas and snow-melt systems.

C405.12

2021 IECC Significant Changes 55

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Additional Efficiency Requirements

Required for prescriptive compliance

- Revised structure of C406
  - Points-based
  - 10 points (credits) required
    - 1 point equivalent to 0.25% energy savings
  - Equity of efficiency options across climate zones
- Expanded options
  - 11 options total, 3 new

C406

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Additional Energy Efficiency Credit Options

1. More efficient HVAC performance
2. Reduced lighting power
3. Enhanced lighting controls
4. On-site supply of renewable energy
5. Dedicated outdoor air systems
6. High-efficiency service water heating
7. Enhanced envelope performance
8. Reduced air infiltration
9. *Energy monitoring system*
10. *Fault detection and diagnostics*
11. *Efficient kitchen equipment*

C406.1

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Credits for Group B Occupancies

TABLE C406.1(5)
ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP B OCCUPANCIES

SECTION	CLIMATE ZONE														
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	1	1	NA	1
C406.2.2: 5% cooling efficiency improvement	6	6	5	5	4	4	3	3	3	2	2	2	1	2	2	2	1
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	1	1	2	2	NA	1
C406.2.4: 10% cooling efficiency improvement	11	12	10	9	7	7	6	5	6	4	4	5	3	4	3	3	3
C406.3: Reduced lighting power	9	8	9	9	9	9	10	8	9	9	7	8	8	6	7	7	6
C406.4: Enhanced digital lighting controls	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1
C406.5: On-site renewable energy	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
C406.6: Dedicated outdoor air	4	4	4	4	4	3	2	5	3	2	5	3	2	7	5	5	3
C406.7.2: Recovered or renewable water heating	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.3: Efficient fossil fuel water heater	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.4: Heat pump water heater	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.8: Enhanced envelope performance	1	4	2	4	4	3	NA	7	4	5	10	7	6	11	10	14	16
C406.9: Reduced air infiltration	2	1	1	2	4	1	NA	8	2	3	11	4	1	15	8	11	6
C406.10: Energy monitoring	4	4	4	4	3	3	3	3	3	3	2	3	2	2	2	2	2
C406.11: Fault detection and diagnostics system	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1

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Credits for Group R and I Occupancies

TABLE C406.1(2)
ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP R AND I OCCUPANCIES

SECTION	CLIMATE ZONE														
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	1	NA	NA	1	NA	1	1	1	1	2	1	2	2
C406.2.2: 5% cooling efficiency improvement	3	3	2	2	1	1	1	1	1	NA	1	1	NA	1	1	1	NA
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	NA	1	NA	NA	1	1	1	2	2	1	3	2	3	4
C406.2.4: 10% cooling efficiency improvement	5	5	4	3	2	3	1	2	2	1	1	1	1	1	1	1	1
C406.3: Reduced lighting power	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C406.4: Enhanced digital lighting controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.5: On-site renewable energy	8	8	8	8	7	8	8	7	7	7	7	7	7	7	7	7	7
C406.6: Dedicated outdoor air system	3	4	3	3	4	2	NA	6	3	4	8	5	5	10	7	11	12
C406.7.2: Recovered or renewable water heating	10	9	11	10	13	12	15	14	14	15	14	14	16	14	15	15	15
C406.7.3: Efficient fossil fuel water heater	5	5	6	6	8	7	8	8	8	9	9	9	10	10	9	10	11
C406.7.4: Heat pump water heater	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C406.8: Enhanced envelope performance	3	6	3	5	4	4	1	4	3	3	4	5	3	5	4	6	6
C406.9: Reduced air infiltration	6	5	3	11	6	4	NA	7	3	3	9	5	1	13	6	8	3
C406.10: Energy monitoring	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C406.11: Fault detection and diagnostics system	1	1	1	1	1	1	NA	1	1	NA	1	1	NA	1	1	1	1

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Requirements for Total Building Performance

- Must have an annual energy cost less than or equal to 80 percent of the standard reference design
  - Standard reference design walls to be the same as proposed
- Must meet requirements of Table C407.2

TABLE C407.2
REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION[a]	TITLE
	Envelope
C402.5	Air leakage—thermal envelope
	Mechanical
C403.1.1	Calculation of heating and cooling loads
C403.1.2	Data centers
C403.2	System design
C403.3	Heating and cooling equipment efficiencies
C403.4, except C403.4.3, C403.4.4 and C403.4.5	Heating and cooling system controls
C403.5.5	Economizer fault detection and diagnostics
C403.7, except C403.7.4.1	Ventilation and exhaust systems
C403.8, except C403.8.6	Fan and fan controls
C403.9	Large-diameter ceiling fans
C403.11, except C403.11.3	Refrigeration equipment performance
C403.12	Construction of HVAC system elements
C403.13	Mechanical systems located outside of the building thermal envelope
C404	Service water heating
C405, except C405.3	Electrical power and lighting systems
C408	Maintenance information and system commissioning

a. Reference to a code section includes all the relative subsections except as indicated in the table.

C407.2

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Appendix CA: Board of Appeals

- Appendix CA provides guidance for establishing a board of appeals, including criteria for membership and instruction for developing rules and procedures
- Consistent with other I-Codes

Appendix CA

61

Appendix CB: Electrical Energy Storage System-Ready Area

- Appendix CB is intended to encourage the installation of renewable energy systems by preparing buildings for the future installation of solar energy equipment, piping and wiring
- New provision for system-ready area for electrical energy storage
  - 2 x 4 ft area on construction docs

Appendix CB

62

Appendix CC: Zero Energy Commercial Building Provisions

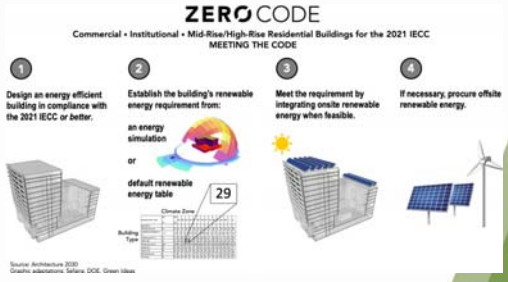
- Appendix CC provides a model for states and jurisdictions to require renewable energy systems capable of achieving net zero carbon
- Applies to new buildings

- Supplemental definitions
  - Adjusted off-site renewable energy
  - Building energy
  - Energy Utilization Intensity (EUI)
  - Off-site renewable energy system
  - On-site renewable energy system
  - Renewable energy system
  - Semiheated space
  - Zero Energy Performance Index (ZEPI PB/EE)

Appendix CC

63

Zero Energy Commercial Building Provisions



Appendix CC

64

Minimum Renewable Energy

CC103.1 Renewable energy. On-site renewable energy systems shall be installed, or off-site renewable energy shall be procured to offset the building energy as calculated in Equation CC-1.

$$RE_{onsite} + RE_{offsite} \geq E_{building} \quad \text{(Equation CC-1)}$$

where:

RE_{onsite} = Annual site energy production from on-site renewable energy systems (see Section CC103.2).

$RE_{offsite}$ = Adjusted annual site energy production from off-site renewable energy systems that may be credited against building energy use (see Section CC103.3).

$E_{building}$ = Building energy use without consideration of renewable energy systems.

- If complying with Total Building Performance or ASHRAE 90.1, building energy is determined from energy simulations
- If complying with the Prescriptive Compliance option, building energy is determined:

gross conditioned floor area + gross semiheated floor area of the proposed building × EUI from Table CC103.1

Appendix CC

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Energy Utilization Intensity

TABLE CC103.1 Energy Utilization Intensity for Building Types and Climates (kBtu/ft² – yr)

Building Area Type	Climate Zone 0A/1A	0B/1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	kBtu/ft²-yr																
Healthcare/hospital (I-2)	119	120	119	113	116	109	106	116	109	106	118	110	105	126	116	131	142
Hotel/motel (R-1)	73	76	73	68	70	67	65	69	66	65	71	68	65	77	72	81	89
Multiple-family (R-2)	43	45	41	41	43	42	36	45	43	41	47	46	41	53	48	53	59
Office (B)	31	32	30	29	29	28	25	28	27	25	29	28	25	33	30	32	36
Restaurant (A-2)	389	426	411	408	444	420	395	483	437	457	531	484	484	589	538	644	750
Retail (M)	46	50	45	46	44	44	37	48	44	44	52	50	46	60	52	64	77
School (E)	42	46	42	40	40	39	36	39	40	40	39	43	37	44	40	45	54
Warehouse (S)	9	12	9	11	12	11	10	17	13	14	23	17	15	32	23	32	32
All others	55	58	54	53	53	51	48	54	52	51	57	54	50	63	57	65	73

Table CC103.1

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Qualifying Off-Site Procurement Methods

1. **Community renewables:** an off-site renewable energy system for which the owner has purchased or leased renewable energy capacity along with other subscribers.
2. **Renewable energy investment fund:** an entity that installs renewable energy capacity on behalf of the owner.
3. **Virtual power purchase agreement:** a power purchase agreement for off-site renewable energy where the owner agrees to purchase renewable energy output at a fixed price schedule.
4. **Direct ownership:** an off-site renewable energy system owned by the building project owner.
5. **Direct access to wholesale market:** an agreement between the owner and a renewable energy developer to purchase renewable energy.
6. **Green retail tariffs:** a program by the retail electricity provider to provide 100-percent renewable energy to the owner.
7. **Unbundled Renewable Energy Certificates (RECs):** certificates purchased by the owner representing the environmental benefits of renewable energy generation that are sold separately from the electric power.

CC103.3.1

67

Residential Significant Changes

Chapter 4 and Appendices

68

Compliance Path Options

- Compliance path options for the residential provisions of the IECC are named and the sections required for each option are outlined
- Tropical Climate Region Option formally recognized as a compliance path

R401.2 Application. Residential buildings shall comply with Section R401.2.5 and either Sections R401.2.1, R401.2.2, R401.2.3 or R401.2.4.

Exception: Additions, *alterations*, repairs and changes of occupancy to existing buildings complying with Chapter 5.

R401.2.1 Prescriptive Compliance Option. The Prescriptive Compliance Option requires compliance with Sections R401 through R404.

R401.2.2 Total Building Performance Option. The Total Building Performance Option requires compliance with Section R405.

R401.2.3 Energy Rating Index Option. The Energy Rating Index (ERI) Option requires compliance with Section R406.

R401.2.4 Tropical Climate Region Option. The Tropical Climate Region Option requires compliance with Section R407.

R401.2

69

Certificate

- Requirements for the certificate are expanded to include
  - Code edition
  - Compliance path
  - Additional energy efficiency option
  - PV system information
  - Energy Rating Index score

R401.3

70

Insulation and Fenestration Criteria

- The assembly U-Factor is established as the primary insulation metric, and R-Value is an alternative.

2018 IECC

R402.1.2 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.2, based on the *climate zone* specified in Chapter 3.

R402.1.4 *U*-factor alternative. An assembly with a *U*-factor equal to or less than that specified in Table R402.1.4 shall be an alternative to the *R*-value in Table R402.1.2.

2021 IECC

R402.1.2 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.2, based on the *climate zone* specified in Chapter 3. Assemblies shall have a *U*-factor equal to or less than that specified in Table R402.1.2. Fenestration shall have a *U*-factor and glazed fenestration SHGC equal to or less than that specified in Table R402.1.2.

R402.1.3 *R*-value alternative. Assemblies with *R*-value of insulation materials equal to or greater than that specified in Table R402.1.3 shall be an alternative to the *U*-factor in Table R402.1.2

R402.1.2 and R402.1.3

71

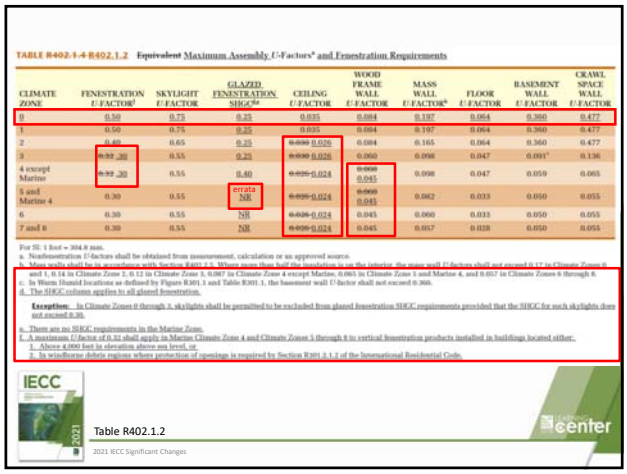


Table R402.1.2

72

TABLE ~~R402.1.2~~ TABLE R402.1.3 Insulation Minimum *R*-values and Fenestration Requirements By Component[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b,k]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b,m]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[f]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,d] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,d] WALL *R*-VALUE
0	NR	0.75	0.25	30	13 or 0 & 10ci[g]	3/4	13	0	0	0
1	NR	0.75	0.25	30	13 or 0 & 10ci[g]	3/4	13	0	0	0
2	0.40	0.65	0.25	~~30~~ 49	13 or 0 & 10ci[g]	4/6	13	0	0	0
3	~~0.35~~ .30	0.55	0.25	~~38~~ 49	20 or ~~13+5~~[h] 13 & 5ci[g] or 0 & 15ci[g]	8/13	19	~~5/13~~ 5ci or 13[f]	~~0~~10ci, 2 ft	~~5/13~~ 5ci or 13[f]
4 except Marine	~~0.35~~ .30	0.55	0.40	~~49~~ 60	30 or 20 & 5ci[g] or 13 & 10ci[g] or 0 & 20ci[g]	8/13	19	~~10/13~~ 10ci or 13	10ci, ~~0~~ 4 ft	~~10/13~~ 10ci or 13
5 and Marine 4	0.30[i]	0.55	errata NR	~~49~~ 60	30 or 20 & 5ci[g] or 13 & 10ci[g] or 0 & 20ci[g]	13/17	30[g]	~~15/19~~ 15ci or 19 or 13 & 5ci	10ci, ~~0~~ 4 ft	~~15/19~~ 15ci or 19 or 13 & 5ci
6	0.30[i]	0.55	NR	~~49~~ 60	30 or 20 & 5ci[g] or 13 & 10ci[g] or 0 & 20ci[g]	15/20	30[g]	~~15/19~~ 15ci or 19 or 13 & 5ci	10ci, 4 ft	~~15/19~~ 15ci or 19 or 13 & 5ci
7 and 8	0.30[i]	0.55	NR	~~49~~ 60	30 or 20 & 5ci[g] or 13 & 10ci[g] or 0 & 20ci[g]	19/21	38[g]	~~15/19~~ 15ci or 19 or 13 & 5ci	10ci, 4 ft	~~15/19~~ 15ci or 19 or 13 & 5ci

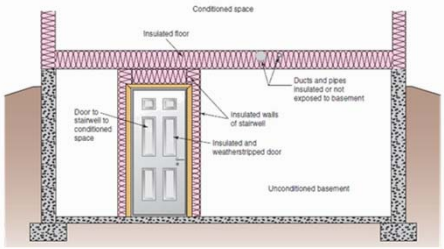
For SI: 1 foot = 304.8 mm.
NR = Not Required.
ci = continuous insulation.

Table R402.1.3

73

Basement Walls & Unconditioned Basements

- Specific criteria must be met for a space to qualify as an unconditioned basement



R402.2.8

74

Air Leakage Testing

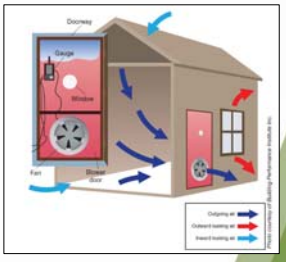
- Reduced maximum air leakage rate to 5 air changes (ACH) per hour for all compliance paths
- Reduced to 3 ACH for climate zones 3-8 for dwellings using the Prescriptive compliance path
  - Exception for heated attached/detached garages
- Alternative compliance method for attached single and multi-family dwelling units and detached dwelling units that are 1,500 ft² or smaller.
  - Limited to .3 cubic feet per minute at 50 Pa

R402.4.1.2 and R402.4.1.3

75

Air Leakage Testing Continued

- Testing conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827
- Testing performed at any time after creation of all penetrations of the building thermal envelope have been sealed

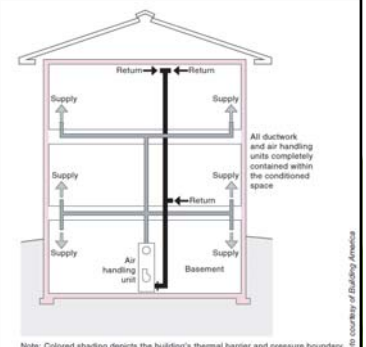


R402.4.1.2

76

Duct Testing

- Testing in accordance with ANSI/RESNET/ICC 380 or ASTM E1554
  - Rough-in test
  - Postconstruction test
- Testing not required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

R403.3.5

77

Duct Testing Continued

- Exception for duct testing of ducts in conditioned spaces is deleted

R403.3.5

78

Duct Leakage

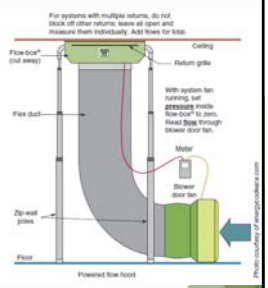
Rough-in Test	Postconstruction	Test for ducts within thermal envelope
• 4.0 cfm/100ft² of conditioned floor area where the air handler is installed at the time of the test • 3.0 cfm/100ft² where air handler not installed	• 4.0 cfm/100ft² of conditioned floor area	• 8.0 cfm/100ft² of conditioned floor area • All ducts and air handlers entirely within building thermal envelope

R403.3.6

79

Mechanical Ventilation System Testing

- Each dwelling is required to have a minimum mechanical ventilation rate per IRC Section M1505
- New provisions for testing not only the whole-house ventilation referenced in the IRC, but also spot ventilation such as bathroom fans
- Kitchen range hoods with ducts 6 inches or larger in diameter are exempt from the requirement



R403.6.3

80

Exterior Lighting

- Connected exterior lighting must comply with the commercial requirements for exterior lighting power, C405.5

Exceptions:

1. Detached one- and two-family dwellings.
2. Townhouses.
3. Solar-powered lamps not connected to any electrical service.
4. Luminaires controlled by a motion sensor.
5. Lamps and luminaires that comply with Section R404.1.

R404.1.1

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Interior Lighting Controls

- Lighting controls required for all permanently installed lighting fixtures
- Exceptions
  - Bathrooms
  - Hallways
  - Exterior lighting fixtures
  - Lighting designed for safety or security

Occupant sensors, dimmers, automatic daylight sensors meet requirements

R404.2

82

Exterior Lighting Controls

Total permanently installed exterior lighting power greater than 30 watts

- Manual on/off switch
  - Exception: lighting serving multiple dwelling units
- Daylight sensor
- Overrides must reset after 24 hours

R404.3

83

Total Building Performance

Table R405.2

2009 IECC backstop for envelope, SHGCs

Annual energy cost less than or equal to annual energy cost of standard reference design

TABLE R405.2
REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION	TITLE
General	
R401.2.5	Additional energy efficiency
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.2.3	Eave baffle
R402.2.4.1	Access hatches and doors
R402.2.10.1	Crawl space wall insulation installation
R402.4.1.1	Installation
R402.4.1.2	Testing
R402.5	Maximum fenestration U-factor and SHGC
Mechanical	
R403.1	Controls
R403.3, including R403.3.1, except Sections R403.3.2, R403.3.3 and R403.3.6	Ducts
R403.4	Mechanical system piping insulation
R403.5.1	Heated-water circulation and temperature maintenance systems
R403.7.3	Drain water heat recovery units
R403.6	Mechanical ventilation
R403.7	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9	Snow melt and ice systems
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
404.2	Interior lighting controls

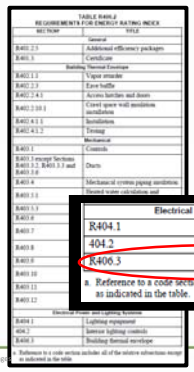
a. Reference to a code section includes all the relative subsections except as indicated in the table

R405.2

84

ERI Compliance

1. Table R406.2



Electrical Power and Lighting Systems	
R404.1	Lighting equipment
404.2	Interior lighting controls
R406.3	Building thermal envelope

a. Reference to a code section includes all of the relative subsections except as indicated in the table.

R406.3 introduces provisions for buildings with and without on-site renewables

- Without on-site renewables
  - Proposed total UA ≤ prescriptive UA × 1.15
- With on-site renewables
  - Back stop of 2018 IECC
  - Credit for renewables limited to 5% of the total home energy use

R406.2

2021 IECC Significant Changes

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ERI Compliance Continued

2. Maximum ERI of Table R406.5

TABLE R406.5 Maximum Energy Rating Index

CLIMATE ZONE	ENERGY RATING INDEX
0-1	~~57~~ 52
2	~~57~~ 52
3	~~57~~ 51
4	~~62~~ 54
5	~~61~~ 55
6	~~61~~ 54
7	~~58~~ 53
8	~~58~~ 53

*Note – these values need reduced by 5% to comply because of the additional efficiency requirement

R406.2 and Table R406.5

2021 IECC Significant Changes

86

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Renewable Energy Certificate (REC) Documentation

Where on-site renewable energy is included in ERI, either:

- Substantiation that the RECs are owned by, or retired on behalf of, the homeowner
- Contract that conveys to the homeowner the RECs associated with the renewable energy

RENEWABLE ENERGY CERTIFICATE (REC). An instrument that represents the environmental attributes of one megawatt hour of renewable energy, also known as an energy attribute certificate (EAC).

R406.7.3

2021 IECC Significant Changes

87

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Additional Energy Efficiency

- Prescriptive Compliance Option
  - Select one additional efficiency package option in Section R408.2
- Total Building Performance option
  - Select one additional efficiency package option in Section R408.2

    OR
  - Proposed design must have annual energy cost less than or equal to 95% of the referenced design
- Energy Rating Index
  - ERI value must be at least 5% less than ERI target

R401.2.5

2021 IECC Significant Changes

88

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Additional Energy Efficiency Package Options

- Enhanced envelope performance
- More efficient HVAC equipment performance
- Reduced energy use in service water heating
- More efficient duct thermal distribution system
- Improved air sealing and efficient ventilation system

R408.2

2021 IECC Significant Changes

89

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Appendix RA: Board of Appeals

- Appendix RA provides guidance for establishing a board of appeals, including criteria for membership and instruction for developing rules and procedures
- Consistent with other I-Codes

Appendix RA

2021 IECC Significant Changes

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Appendix RB: Solar-Ready Provisions

- Appendix RB does not require solar systems to be installed for a building
- It requires the space for installing such systems, providing pathways for connections and requiring adequate structural capacity of roof systems to support the systems
- Shading
  - Panel placement zones based on existing or permanently installed site elements
- Capped roof penetration sleeve
  - Provided on roofs with less than 1/12 pitch

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Appendix RC: Zero Energy Residential Building Provisions

ERI zero energy score for compliance

- ERI values calculated in accordance with RESNET/ICC 301 with and without on-site power production (OPP)

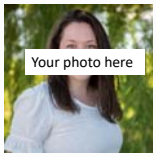
TABLE RC102.2 Maximum Energy Rating Index[a]

CLIMATE ZONE	ENERGY RATING INDEX not including OPP	ENERGY RATING INDEX including Adjusted OPP [as proposed]
1	43	0
2	45	0
3	47	0
4	47	0
5	47	0
6	46	0
7	46	0
8	46	0

a. The building shall meet the requirements of Table R406.2, and the building thermal envelope shall be greater than or equal to the levels of efficiency and SHGC in Table R402.1.2 or Table R402.1.3 of the 2015 International Energy Conservation Code.

92

Thank you for participating!



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File Attachments for Item:

EC-7 2021 Plumbing, Mechanical, and Gas Update (International Code Council)

All certifications (2 hours)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: 2021 PMG Update

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable) ICC Conference Email: _____

Check here if Course Renewal: _____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2021 PMG Update

Course instructor: Jim Cika

Course description: This session introduces participants to the major changes from the 2018 IPC, IMC and IFGC to the 2021 IPC, IMC and IFGC. Participants will discuss how to apply code requirements to design, plan submittals and/or inspection.

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: 05/01/2023 / Tampa Bay, FL

Special Content:

Code Administration: _____

Existing Buildings: _____

Electrical Instruction: _____

Plumbing Instruction: X

Conference Course: 2021 PMG Update

Conference Name: ICC Spring Interchange

Conference location: Tampa Bay, FL

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: https://www.iccsafe.org/about/news-and-events/annual-conferences-hearings/sessions-s23#m1a

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
N/A

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

- ✓ Course Outline or Course Learning Objectives
- ✓ Presentation Materials/Slides (not required for roundtable courses)
- _____ Assessment Materials (for online courses)
- ✓ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2021 IPC, IMC, IFGC® Significant Changes

Based on the 2021 International Plumbing Code® (IPC®)

Based on the 2021 International Mechanical Code® (IMC®)

Based on the 2021 International Fuel Gas Code® (IFGC®)

SKU #	Product #

Length:	2 Hr (2 Contact Hours)
Applicable Codes:	2021 IPC, IMC, and IFGC
Product Type/Status:	Seminar - Update
Level:	Entry

Background Information

Description

This seminar introduces participants to the major changes from the 2018 IPC, IMC and IFGC to the 2021 IPC, IMC and IFGC. Participants will discuss the changes, reasons for the changes, and take part in knowledge review activities. Information presented will allow participants to apply these new code requirements to design, plan review, and/or inspection.

Goal

Participants will be able to use this document to identify changes from the 2018 IPC, IMC and IFGC to the 2021 IPC, IMC and IFGC, allowing them to apply these code requirements to the design, plan and/or inspection.

Objectives

Upon completion of this seminar, participants will be better able to:

- Identify the most significant differences between the 2018 IPC, IMC and IFGC and the 2021 IPC, IMC and IFGC.
- Explain the differences between the current and previous edition.
- Identify changes in organization and code requirements.
- Identify the applicability of design, plan review and inspection requirements

Target Audience

Building Officials, Architects, Building Inspectors, Contractors, Engineers, Plans Examiners, Plumbing Inspectors

Prerequisites

Participants will be at the beginning level, which means they should be able to do or know the following before they participate in this training:

- Be familiar with the IPC, IMC, and IFGC
- Know basic construction terminology, techniques, methods and materials
- Reads basic construction document.

Timed Outline

Outline of Seminar **(2 hours = 120 minutes)**

I. Introduction (5 minutes)
- **A.** Speaker introduction
- **B.** Scope and objectives

II. IPC Significant Changes (45 minutes)
- **A.** Chapter 2: Definitions
- **B.** Chapter 3: 308.2
- **C.** Chapter 4: 403.1.1, 403.1.2, 403.2, 403.3.3, 403.6, 405.4.3, 407.2, 410.3.2, 410.4, 411.3, 412.3, 412.5, 412.10, 421.3.1
- **D.** Chapter 6: 602.3.5, 606.1, 607.1.1, 607.1.2, 608.15.2.1, 609.2, 609.2.1
- **E.** Chapter 7: 705.2.4, 705.10.4, 708.1.6, 717, 718
- **F.** Chapter 9: 903.1.3, 915.1
- **G.** Chapter 10: 1002.1, 1002.4.1.5
- **H.** Chapter 11: 1102.6, 1106.2.1
- **I.** Chapter 13: 1301.1

III. IMC Significant Changes (40 minutes)
- **A.** Chapter 2 Definitions
- **B.** Chapter 3: 301.18, 307.1.1, 307.2.3.3, 307.2.1.1,
- **C.** Chapter 4: 401.2, 403.1, 401.4, 403.2.1.2, Table 403.3.1.1 Note g, Table 403.3.1.1, 403.3.1.3, 403.3.2.1
- **D.** Chapter 5: 501.3.1, 502.20, 504.4.1, 504.6, 506.3.7, 506.3.9, 507.1, 514.2
- **E.** Chapter 6: 602.2.1.8, 607.5.2, 607.5.5, 608.1
- **F.** Chapter 8: 801.21
- **G.** Chapter 9: 905.1, 920.4, 929.1
- **H.** Chapter 11: 1101.1, 1101.1.2, Table 1101.2, Table 1103.1, 1105.9, 1107-1110
- **I.** Chapter 12: 1203.7
- **J.** Chapter 13: 1303.3, 1303.3.2, 1303.3.5, 1303.4

IV. IFGC Significant Changes (25 minutes)
- **A.** Chapter 2: Definitions
- **B.** Chapter 3: 307.2
- **C.** Chapter 4: 402.7, 403.8.3, 404.5
- **D.** Chapter 5: 503.5.6.1, 503.8, Table 503.8, Figure 503.8, 503.10.7
- **E.** Chapter 6: 614.7, 618.6, 623.2

V. Summary and Q&A (5 minutes)

Please allow time for breaks at natural intervals.

Jim Cika, director of Government Relations Plumbing, Mechanical, Fuel Gas and Swimming Pool & Spa (PMG) resources for the International Code Council, has more than 20 years of experience in the manufacturing and construction industry. Most recently, he was the director of engineering and product management at HTP Comfort Solutions, a heating and hot water appliance manufacturing company. Cika was a member of the executive team responsible for HTP's product research, design, development and testing activities, and he served as the company's chief technical expert for regulatory, product standards, building code and product engineering matters.

Previously, Cika served as manager for solar products for Heliodyne and Velux America (both members of the Velux Group), where he was responsible for developing and expanding their solar water heater businesses in North America. Cika also worked for Rheem Water Heating, and prior to that Rinnai America. His primary responsibility for both companies was the development and launching of their tankless water heater product lines in North America.

Earlier in his career, Cika was with Atlanta Gas Light Company, where he gained extensive experience related to the performance and safety of gas appliances. He also has prior experience as an HVAC design engineer.

Cika has a degree in mechanical engineering from the Georgia Institute of Technology.

2021 PMG Significant Changes

Based on the 2021 International Plumbing Code®, (IPC®), 2021 International Mechanical Code®, (IMC®), and 2021 International Fuel Gas Code®, (IFGC®)

1

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GOAL

Identify significant changes between the 2018 and 2021 IPC, IMC, and IFGC

Apply code requirements to design, plan submittals and/or inspection

3

Objectives

- Explain the key differences between the 2018 and the 2021 Codes
- Identify changes in organization and code requirements
- Apply the codes to design, plan review, and inspection requirements

4

Informational Icons

Addition | Deletion | Modification | Clarification

5

2021 International Plumbing Code

Based on the 2021 International Plumbing Code®, (IPC®)

6

Chapter 2

Definitions

7

Section 202 Definition
Public and Private

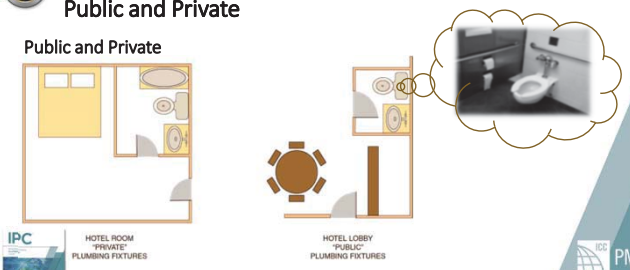
PUBLIC OR PUBLIC UTILIZATION. In the classification of plumbing fixtures, "public" applies to fixtures ~~in general toilet rooms of schools, gymnasiums, hotels, airports, bus and railroad stations, public buildings, bars, public comfort stations, office buildings, stadiums, stores, restaurants and other installations where a number of fixtures are installed so that their utilization is similarly unrestricted~~ with unrestricted exposure to walk-in traffic.

PRIVATE. In the classification of plumbing fixtures, "private" applies to fixtures ~~in residences and apartments, and to fixtures in nonpublic toilet rooms of hotels and motels and similar installations in buildings where the plumbing fixtures are intended for utilization by a family or an individual~~ that are not public.

8

Section 202 Definition
Public and Private

Public and Private



9

Section 202 Definition
Water Dispenser

WATER DISPENSER. A plumbing fixture that is manually controlled by the user for the purpose of dispensing potable drinking water into a receptacle such as a cup, glass or bottle. Such fixture is connected to the potable water distribution system of the premises. ~~This definition includes a freestanding apparatus for the same purpose that is not connected to the potable water distribution system and that is supplied with potable water from a container, bottle or reservoir.~~

410.4 Substitution. Where restaurants provide drinking water in a container free of charge, drinking fountains shall not be required in those restaurants. In other *occupancies* where three or more drinking fountains are required, *water dispensers* shall be permitted to be substituted for not more than 50 percent of the required number of drinking fountains.

10

Chapter 3

General Regulations

11

308.2 Piping Seismic Support

308.2 Piping seismic supports. Where earthquake loads are applicable in accordance with the International Building Code, plumbing piping supports, anchorage, and bracing shall be designed and installed for ~~the~~ seismic forces in accordance with Chapter 16 of the *International Building Code*.

12

Chapter 4

Fixtures, Faucets, and Fixture Fittings

13

403.1.1 Fixture Calculations

403.1.1 Fixture calculations. Text remains unchanged.

Exceptions:

1. [Text unchanged.]
2. Where multiple-user facilities are designed to serve all genders, the minimum fixture count shall be calculated 100 percent, based on total occupant load. In such multiple-user facilities, each fixture type shall be in accordance with ICC A117.1 and each urinal that is provided shall be located in a stall.
3. Distribution of the sexes is not required where single-user water closets and bathing room fixtures are provided in accordance with Section 403.1.2.

14

403.1.2 Fixtures in Single-user Toilet Rooms Count Towards Total Required Quantities

403.1.2 Single-user toilet ~~facility~~ and bathing room fixtures. The plumbing fixtures located in single-user toilet ~~facilities~~ and bathing rooms, including family or assisted-use toilet and bathing rooms that are required by Section 1109.2.1 of the *International Building Code*, shall contribute toward the total number of required plumbing fixtures for a building or tenant space. Single-user toilet ~~facilities~~ and bathing rooms, and family or assisted-use toilet rooms and bathing rooms shall be identified as being available for use ~~either~~ by all persons regardless of their sex.

The total number of fixtures shall be permitted to be based on the required number of separate facilities or based on the aggregate of any combination of single-user or separate facilities.

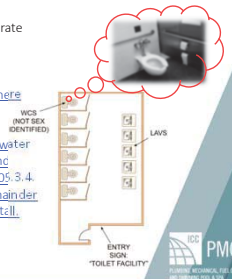
15

403.2 Multiple-user Nonseparated Toilet Facilities

403.2 Separate facilities. Where plumbing fixtures are required, separate facilities shall be provided for each sex.

Exceptions:

1. through 4. remain unchanged.
5. Separate facilities shall not be required to be designated by sex where single-user toilets rooms are provided in accordance with Section 403.1.2.
6. Separate facilities shall not be required where rooms having both water closets and lavatory fixtures are designed for use by both sexes and privacy for water closets is provided in accordance with Section 405.3.4. Urinals shall be located in an area visually separated from the remainder of the facility or each urinal that is provided shall be located in a stall.



16

403.3.3 Group S Toilet Facility Location

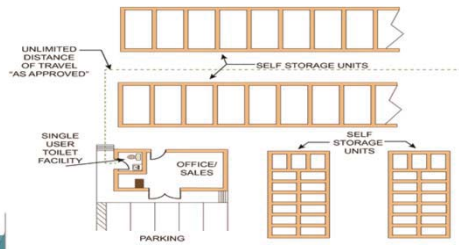
403.3.3 Location of toilet facilities in occupancies other than malls. In occupancies other than covered and open mall buildings, the required public and employee toilet facilities shall be located not more than one story above or below the space required to be provided with toilet facilities, and the path of travel to such facilities shall not exceed a distance of 500 feet (152 m).

Exceptions:

1. The location and maximum distances of travel to required employee facilities in factory and industrial occupancies shall be permitted to exceed that required by this section, provided that the location and maximum distances of travel are approved.
2. The location and maximum distances of travel to required public and employee facilities in Group S occupancies shall be permitted to exceed that required by this section, provided that the location and maximum distances of travel are approved.

17

403.3.3 Group S Toilet Facility Location

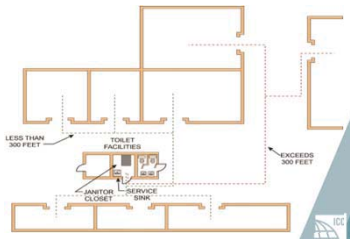


Storage Facility with Toilet Facility at Office

18

403.6 Service Sink Location

403.6 Service sink location. Service sinks shall not be required to be located in individual tenant spaces in a covered mall provided that service sinks are located within a distance of travel of 300 feet (91 m) of the most remote location in the tenant space and not more than one story above or below the tenant space. Service sinks shall be located on an accessible route.

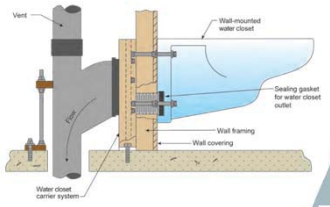


Location of service sink

19

405.4.3 Wall Hung Fixture Carrier Standard for Water Closets

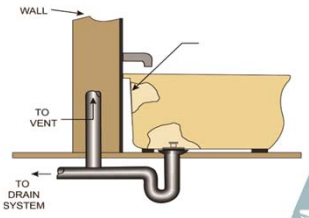
405.4.3 Securing wall-hung water closet bowls. Wall-hung water closet bowls shall be supported by a concealed metal carrier that is attached to the building structural members so that strain is not transmitted to the ~~closet~~ fixture connector or any other part of the plumbing system. The carrier shall conform to ASME A112.6.1M or ASME A112.6.2.



20

407.2 Bathtub Waste Outlets and Overflow

407.2 Bathtub waste outlets and overflows. Bathtubs shall be equipped with a waste outlet ~~and an overflow outlet. The outlets shall be connected to waste tubing or piping~~ that is not less than 1½ inches (38 mm) in diameter. The waste outlet shall be equipped with a watertight stopper. Where an overflow is installed, the overflow shall be not less than 1½ inches (38 mm) in diameter.



21

410.3.2 Quantities of Standing versus Wheelchair Drinking Fountains

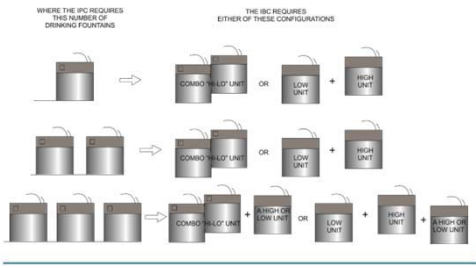
410.3.2 More than the minimum number. Where more than the minimum number of drinking fountains specified in Section 410.3.1 is provided, 50 percent of the total number of drinking fountains provided shall comply with the requirements for persons who use a wheelchair and 50 percent of the total number of drinking fountains provided shall comply with the requirements for standing persons.

Exceptions:

1. Where 50 percent of the drinking fountains yields a fraction, 50 percent shall be permitted to be rounded up or down, provided that the total number of drinking fountains complying with this section equals 100 percent of the drinking fountains.
2. Where drinking fountains are primarily for children's use, drinking fountains for people using wheelchairs shall be permitted to comply with the children's provisions in ICC A117.1 and drinking fountains for standing children shall be permitted to provide the spout at 30 inches (762 mm) minimum above the floor.

22

410.3.2 High and Low Drinking Fountains



23

410.4 Drinking Fountain Substitution using Water Dispensers

410.4 Substitution. Where restaurants provide drinking water in a container free of charge, drinking fountains shall not be required in those restaurants. In other occupancies where three or more drinking fountains are required, water dispensers shall be permitted to be substituted for not more than 50 percent of the required number of drinking fountains.

24

411.3 Water Heaters for Emergency Showers and Eye Wash Stations

411.3 Water supply. Where hot and cold water is supplied to an emergency shower or eyewash station, the temperature of the water supply shall only be controlled by a temperature-actuated mixing valve complying with ASSE 1071. Where water is supplied directly to an emergency shower or eyewash station from a water heater, the water heater shall comply with ASSE 1085.

25

412.3 Shower Control Valves to be Rated for the Installed Shower Head

412.3 Individual shower valves. Individual shower and tub-shower combination valves shall be balanced-pressure, thermostatic or combination balanced-pressure/thermostatic valves that conform to the requirements of ASSE 1016/ASME A112.1016/CSA B125.16 or ASME A112.18.1/CSA B125.1. Such valves shall be installed at the point of use. Shower control valves shall be rated for the flow rate of the installed shower head. Shower and tub-shower combination valves required by this section shall be equipped with a means to limit the maximum setting of the valve to 120°F (49°C), which shall be field adjusted in accordance with the manufacturer's instructions to provide water at a temperature not to exceed 120°F (49°C). In-line thermostatic valves shall not be utilized for compliance with this section.

26

412.5 Methods for Limiting Water Temperature Discharged to Bathtubs

412.5 Bathtub and whirlpool bathtub valves. ~~The hot water supplied to~~ Bathtubs and whirlpool bathtub valves shall ~~be limited to not greater than~~ have or be supplied by a water-temperature-limiting device that conforms to ASSE 1070/ASME A112.1070/CSA B125.70 or by a water heater complying with ASSE 1082 or ASSE 1084, except where ~~such protection is otherwise provided by a~~ such valves are combination tub/shower valves in accordance with Section 412.3. The water-temperature-limiting device required by this section shall be equipped with a means to limit the maximum setting of the device to 120°F (49°C), and, where adjustable, shall be field adjusted in accordance with the manufacturer's instructions to provide hot water at a temperature not to exceed 120°F (49°C). Access shall be provided to water-temperature-limiting devices that conform to ASSE 1070/ASME A112.1070/CSA B125.70.

27

412.10 Temperature Limitation at Head Shampoo Sinks

412.10 Head shampoo sink faucets. Head shampoo sink faucets shall be supplied with hot water that is limited to not more than 120°F (49°C) ~~by a water-temperature-limiting device that conforms to ASSE 1070/ASME A112.1070/CSA B125.70.~~ Each faucet shall have integral check valves to prevent crossover flow between the hot and cold water supply connections. The means for regulating the maximum temperature shall be one of the following:

1. A limiting device conforming to ASSE 1070/ASME A112.1070/CSA B125.70.
2. A water heater conforming to ASSE 1082.
3. A temperature-actuated, flow-reduction device conforming to ASSE 1062.

28

421.3.1 Standard for Shower Waste Fittings

421.3.1 Waste fittings. Waste fittings shall conform to ASME A112.18.2/CSA B125.2.

29

Chapter 6

Water Supply and Distribution

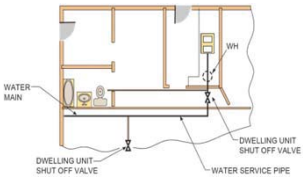
30

602.3.5 Potable Water Pumps to Comply with NSF

602.3.5 Pumps. Pumps shall be rated for the transport of potable water. Pumps in an individual water supply system shall be constructed and installed so as to prevent contamination from entering a potable water supply through the pump units. Pumps intended to supply drinking water shall conform to NSF 61. Pumps shall be sealed to the well casing or covered with a water-tight seal. Pumps shall be designed to maintain a prime and installed such that ready access is provided to the pump parts of the entire assembly for repairs.

31

606.1 Individual Tenant Water Shut-off Valve



606.1 Location of full-open valves. Full-open valves shall be installed in the following locations:

1. On the building water service pipe from the public water supply near the curb.
2. On the water distribution supply pipe at the entrance into the structure.

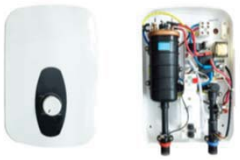
2.1. In multiple-tenant buildings, where a common water supply piping system is installed to supply other than one- and two-family dwellings, a main shutoff valve shall be provided for each tenant.

(3. through 8. remain unchanged)

32

607.1.1 Water Heaters Providing Tempered Water to Fixtures

607.1.1 Temperature limiting means. A thermostat control for a water heater shall ~~not~~ only serve as the temperature limiting means for the purposes of complying with the requirements of this code for maximum allowable hot or tempered water delivery temperature at fixtures where the water heater complies with ASSE 1082 or ASSE 1085.



33

607.1.2 Tempered Water Temperature Control

607.1.2 Tempered water temperature control. Tempered water shall be ~~supplied through a water temperature~~ controlled by one of the following:

1. A limiting device ~~that conforms~~ conforming to ASSE 1070/ASME A112.1070/CSA B125.70 ~~and shall limit the tempered water to not greater than~~ and set to not greater than 110°F (43°C).
2. A thermostatic mixing valve conforming to ASSE 1017.
3. A water heater conforming to ASSE 1082.
4. A water heater conforming to ASSE 1084.

This provision shall not supersede the requirement for protective shower valves in accordance with Section 412.3.

34

608.15.2.1 Discharge from Backflow Preventer Relief Opening

608.15.2.1 Relief port piping. The termination of the piping from the relief port or air gap fitting of a backflow preventer shall discharge to an approved indirect waste receptor or to the outdoors where it will not cause damage or create a nuisance. The indirect waste receptor and drainage piping shall be sized to drain the maximum discharge flow rate from the relief port as published by the backflow preventer manufacturer.

35

609.2 Two Water Service Pipes for Group I-2, Condition 2 Healthcare Facilities

609.2 Water service for Group I-2, Condition 2 facilities. ~~Hospitals~~ Group I-2, Condition 2 facilities shall have not fewer than two water service pipes ~~installed in such a manner so as to minimize the potential for an interruption of the supply of water in the event of a water main or water service pipe failure.~~ sized such that with the loss of the largest service pipe, the remaining service pipes will meet the water demand for the entire facility. Each water service shall have a shutoff valve in the building and a shutoff valve at the utility-provided point of connection to the water main or other source of potable water.

36

609.2.1 Tracer Wire for Buried Nonmetallic Water Service Piping

609.2.1 Tracer wire for nonmetallic piping. An insulated tracer wire listed for the purpose or other approved conductor shall be installed adjacent to underground nonmetallic piping serving as a water service for a hospital. Access shall be provided to the tracer wire or the tracer wire shall terminate above ground at each end of the nonmetallic piping. The tracer wire size shall be not less than 18 AWG and the wire insulation type shall be suitable for direct burial.

37

Chapter 7

Sanitary Drainage

38

705.2.4, 705.10.4 PVC and ABS Push-fit DWV Fittings

705.2.4 Push-fit joints. Push-fit DWV fittings shall be listed and labeled to ASME A112.4.4 and shall be installed in accordance with the manufacturer's instructions.

705.10.4 Push-fit joints. Push-fit joints shall conform to ASME A112.4.4 and shall be installed in accordance with the manufacturer's instructions.

39

708.1.6 Removable Fixture Traps Serving as Cleanouts

708.1.6 Cleanout equivalent. A fixture trap or a fixture with integral trap, removable without altering concealed piping, shall be acceptable as a cleanout equivalent.

40

717 Methods for Restoring Building Sewer Piping

SECTION 717 RELINING BUILDING SEWERS AND BUILDING DRAINS

717.1 General. This section shall govern the relining of existing building sewers and building drainage piping.

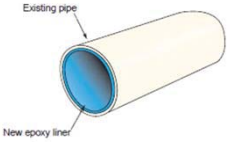
717.2 Applicability. The relining of existing building sewers and building drainage piping shall be limited to gravity drainage piping 4 inches (102 mm) in diameter and larger. The relined piping shall be of the same nominal size as the existing piping.

41

718 Methods for Restoring Building Sewer Piping

SECTION 718 REHABILITATION OF BUILDING SEWERS AND BUILDING DRAINS

718.1 Cure-in-place. Sectional cure-in-place rehabilitation of building sewer piping and sewer service lateral piping shall be in accordance with ASTM F2599. Main and lateral cure-in-place rehabilitation of building sewer and sewer service lateral pipe and their connections to the main sewer pipe shall be in accordance with ASTM F2561. Hydrophilic rings or gaskets in cure-in-place rehabilitation of building sewer piping and sewer service laterals shall be in accordance with ASTM F3240 to ensure water tightness and elimination of ground water penetration.



42

Chapter 9

Vents

43

903.1.3 Protected Outdoor Vent Termination Method

903.1.3 Protected vent terminal. Where an open vent pipe terminates above a sloped roof and is covered by either a roof mounted panel (such as a solar collector or photovoltaic panel mounted over the vent opening) or a roof element (such as an architectural feature or a decorative shroud), the vent pipe shall terminate not less than 2 inches (51 mm) above the roof surface. Such roof elements shall be designed to prevent the adverse effects of snow accumulation and wind on the function of the vent. The placement of a panel over a vent pipe and the design of a roof element covering the vent pipe shall provide for an open area for the vent pipe to the outdoors that is not less than the area of the pipe, as calculated from the inside diameter of the pipe. Such vent terminals shall be protected by a method that prevents birds and rodents from entering or blocking the vent pipe opening.

44

915.1 Food Waste Disposers on Combination Waste and Vent Systems

915.1 Type of fixtures. A combination waste and vent system shall not serve fixtures other than floor drains, sinks, lavatories and drinking fountains. Combination waste and vent systems shall not receive the discharge from a ~~food waste disposer or~~ clinical sink.

45

Chapter 10

Traps, Interceptors and Separators

46

1002.1 Direct Connection to Hydromechanical Grease Interceptor

1002.1 Fixture traps.

Exceptions:

4. Where a hydromechanical grease interceptor serves a food utensil, dishes, pots-and-pans sink, in accordance with the manufacturer's installation instructions. The branch drain serving the interceptor shall be provided with an emergency floor drain downstream of the interceptor connection, and the branch shall serve only the emergency floor drain and the interceptor. Where the interceptor serves a combination sink of not more than three compartments where the vertical distance from the fixture outlet to the inlet of the interceptor does not exceed 30 inches (762 mm) and the developed length of the waste pipe from the most upstream fixture outlet to the inlet of the interceptor does not exceed 60 inches (1524 mm). The food utensil, dishes, pots and pans sink shall be required to connect directly with the interceptor.

47

1002.4.1.5 Fixture Drains Serving as a Trap Priming Method

1002.4.1.5 Fixture drain connection for trap priming. A fixture drain from a lavatory or hand sink shall serve as a method of providing trap seal protection for an emergency floor drain, a trench drain, or a floor sink where such fixtures are located in the same room. A fixture drain from a drinking fountain shall serve as a method of providing trap seal protection for an emergency floor drain, a trench drain, or a floor sink where such fixtures are in the same room or in a room adjacent to the room having the drinking fountain. The fixture drain shall not be routed on or above the surface of the floor and shall connect to the floor drain, trench drain, or floor sink at a point that is below the flood level rim and above the inlet to the trap of the receiving fixture.

48

Chapter 11

Storm Drainage

49

1102.6 Roof Drains to be Tested and Rated for Flow

1102.6 Roof drains. Roof drains shall conform to ASME A112.3.1 or ASME A112.6.4. Roof drains, other than siphonic roof drains, shall be tested and rated in accordance with ASME A112.6.4 or ASPE/IAPMO Z1034.

50

1106.2.1 Rainfall Rate Conversion Method

1106.2.1 Rainfall rate conversion method. The rainfall rate falling on a roof surface shall be converted to a gallon per minute (L/m) flow rate in accordance with Equation 11-1.

GPM = R x A x 0.0104 (Equation 11-1)

where,

R = Rainfall intensity in inches per hour

A = Roof area in square feet

51

Chapter 13

Nonpotable Water Systems

52

1301.1 Nonpotable Rainwater Standard Alternative

1301.1 ~~Scope~~ General. The provisions of Chapter 13 shall govern the materials, design, construction and installation of systems for the collection, storage, treatment and distribution of nonpotable water. For nonpotable rainwater systems, the provisions of CSA B805/ICC 805 shall be an alternative for regulating the materials, design, construction and installation of systems for rainwater collection, storage, treatment and distribution of nonpotable water. The use and application of nonpotable water shall comply with laws, rules and ordinances applicable in the jurisdiction.

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Discussion

54

2021 International Mechanical Code®, IMC®

Based on the 2021 International Mechanical Code®

55

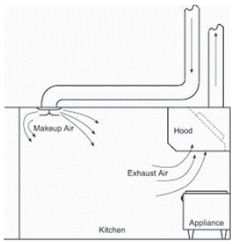
Chapter 2

Definitions

56

Section 202 Definition of Balanced Ventilation

2021 CODE: **BALANCED VENTILATION.** Any combination of concurrently operating mechanical exhaust and mechanical supply whereby the total mechanical exhaust airflow rate is within 10 percent of the total mechanical supply airflow rate.



57

Section 202 Definition of Unvented Alcohol Fuel Burning Decorative Appliance

2021 CODE: **UNVENTED ALCOHOL FUEL-BURNING DECORATIVE APPLIANCE.** A stationary, self-contained appliance intended to be directly or indirectly secured to a wall or floor and not intended for duct connection. Such appliance burns alcohol and is made in a manufacturing facility for subsequent delivery to the installation site.

Unvented alcohol fuel-burning decorative appliance

58

Chapter 3

General Regulations

59

301.18 Seismic resistance

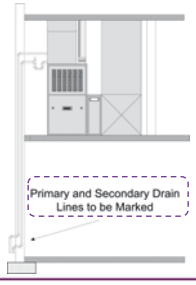
2021 CODE: **301.18 Seismic resistance.** Where earthquake loads are applicable in accordance with the International Building Code, mechanical system supports, anchorage ~~and bracing~~ shall be designed and installed for ~~the~~ seismic forces in accordance with Chapter 16 of the International Building Code.

60

307.1.1, 307.2.3.3 Identification

(Fuel–burning appliances) 307.1.1 Identification. The termination of concealed condensate piping shall be marked to indicate whether the piping is connected to the primary or to the secondary drain.

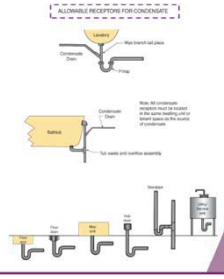
(Evaporators and Cooling coils) 307.2.3.3 Identification. The termination of concealed condensate piping shall be marked to indicate whether the piping is connected to the primary or to the secondary drain.



61

307.2.1.1 Condensate Discharge

2021 CODE: 307.2.1.1 Condensate discharge. Condensate drains shall not directly connect to any plumbing drain, waste or vent pipe. Condensate drains shall not discharge into a plumbing fixture other than a floor sink, floor drain, trench drain, mop sink, hub drain, standpipe, utility sink or laundry sink. Condensate drain connections to a lavatory wye branch tailpiece or to a bathtub overflow pipe shall not be considered as discharging to a plumbing fixture. Except where discharging to grade outdoors, the point of discharge of condensate drains shall be located within the same occupancy, tenant space or dwelling unit as the source of the condensate.



62

Chapter 4

Ventilation

63

401.2 Ventilation Required

Mechanical Ventilation for Dwelling Units

2021 CODE: **401.2 Ventilation required.** Every occupied space shall be ventilated by natural means in accordance with Section 402 or by mechanical means in accordance with Section 403. ~~Where the air infiltration rate in a dwelling unit is less than 5 air changes per hour when tested with a blower door at a pressure of 0.2 inch water column (50 Pa) in accordance with Section R402.4.1.2 of the International Energy Conservation Code, the dwelling unit shall be ventilated by mechanical means in accordance with Section 403. Ambulatory care facilities and Group I-2 occupancies.~~ Dwelling units complying with the air leakage requirements of the International Energy Conservation Code or ASHRAE 90.1 shall be ventilated by mechanical means in accordance with Section 403. Ambulatory care facilities and Group I-2 occupancies shall be ventilated by mechanical means in accordance with Section 407.

64

403.1 Ventilation System

Mechanical Ventilation for Dwelling Units

2021 CODE: **403.1 Ventilation system.** Mechanical ventilation shall be provided by a method of supply air and return or exhaust air except that mechanical ventilation air requirements for Group R-2, R-3 and R-4 occupancies ~~three stories and less in height above grade plane~~ shall be provided by an exhaust system, supply system or combination thereof. The amount of supply air shall be approximately equal to the amount of return and exhaust air . The system shall not be prohibited from producing negative or positive pressure. The system to convey ventilation air shall be designed and installed in accordance with Chapter 6.

65

401.4 Intake Opening Location

2021 CODE: **401.4 Intake opening location.** Air intake openings shall comply with all of the following:
1. and 2. (Text remains unchanged)
3. Intake openings shall be located not less than 3 feet (914 mm) below contaminant sources where such sources are located within 10 feet (3048 mm) of the opening. Separation is not required between intake air openings and living space exhaust air openings of an individual dwelling unit or sleeping unit where an approved factory-built intake/exhaust combination termination fitting is used to separate the air streams in accordance with the manufacturer's instructions.
4. (Text remains unchanged)

66

403.2.1.2 Recirculation of Air to a Swimming Pool and Associated Deck Areas

2021 CODE: **403.2.1 Recirculation of air.** The outdoor air required by Section 403.3 shall not be recirculated. Air in excess of that required by Section 403.3 shall not be prohibited from being recirculated as a component of supply air to building spaces, except that:

1. (Text remains unchanged).
2. Supply air to a swimming pool and associated deck areas shall not be recirculated unless such air is dehumidified to maintain the relative humidity of the area at 60 percent or less. Air from this area shall not be recirculated to other spaces where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces. The design and installation of dehumidification systems shall comply with ANSI/ACCA 10 Manual SPS.
3. and 4. (Text remains unchanged).

67

Table 403.3.1.1 Minimum Ventilation Rates

2021 CODE: Table 403.3.1.1 Minimum Ventilation Rates

Occupancy Classification	Occupant Density #/1000 Ft²ᵃ	People Outdoor Airflow Rate in Breathing Zone, R_p CFM/Person	Area Outdoor Airflow Rate in Breathing Zone, R_a CFM/Ft²ᵃ	Exhaust Airflow Rate CFM/Ft²ᵃ
Commercial Laundry	10	~~25~~ 5	0.12	-
Kitchens[b]	-	-	-	~~25~~ 50/100f
Toilet rooms and bathrooms	-	-	-	~~20~~ 25/50f

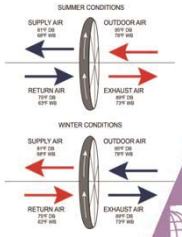
68

Note g, Table 403.3.1.1 Recirculation of Mechanical Exhaust Prohibited

2021 CODE: **Table 403.3.1.1 Minimum Ventilation Rates**

Note g: Mechanical exhaust is required and recirculation from such spaces is ~~prohibited except that recirculation shall be permitted where the resulting supply airstream consists of not more than 10 percent air recirculated from these spaces.~~ prohibited. For occupancies other than science laboratories, where there is a wheel-type energy recovery ventilation (ERV) unit in the exhaust system design, the volume of air leaked from the exhaust airstream into the outdoor airstream within the ERV shall be less than 10 percent of the outdoor air volume. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Items 2 and 4).

(No changes to notes a through f; No changes to note h)



69

403.3.1.3 Demand Controlled Ventilation

2021 CODE: **403.3.1.3 System operation.** The minimum flow rate of outdoor air that the ventilation system must be capable of supplying during its operation shall be permitted to be based on the rate per person indicated in Table 403.3.1.1 and the actual number of occupants present. Where demand-controlled ventilation is employed to adjust the outdoor airflow rate based on the actual number of occupants present, the minimum quantity of outdoor air shall not fall below that determined from the area outdoor airflow rate column of Table 403.3.1.1 during periods when the building is expected to be occupied.

70

403.3.2.1 Outdoor Air for Dwelling Units

2021 CODE: **403.3.2.1 Outdoor air for dwelling units.** "Text Unchanged"
(Equation 4-9) "Unchanged"

Exceptions:

1. (Text remains unchanged).
2. The minimum mechanical ventilation rate determined in accordance with Equation 4.9 shall be reduced by 30%, provided that both of the following conditions apply:
   2.1. A ducted system supplies ventilation air directly to each bedroom and to one of the following rooms:
      2.1.1. Living Room
      2.1.2. Dining Room
      2.1.3. Kitchen
   2.2. The whole-house ventilation system is a balanced ventilation system.

71

Chapter 5

Exhaust Systems

72

501.3.1 Location of Exhaust Opening

2021 CODE: 501.3.1 Location of exhaust outlets. The termination point of exhaust outlets and ducts discharging to the outdoors shall be located with the following minimum distances:

1. and 2. (Text remains unchanged)

3. For all environmental air exhaust: 3 feet (914 mm) from property lines; 3 feet (914 mm) from operable openings into buildings for all occupancies other than Group U; and 10 feet (3048 mm) from mechanical air intakes. Such exhaust shall not be considered hazardous or noxious. Separation is not required between intake air openings and living space exhaust air openings of an individual dwelling unit or sleeping unit where an approved factory-built intake/exhaust combination termination fitting is used to separate the air streams in accordance with the manufacturer's instructions.

4. and 5. (Text remains unchanged)

73

502.20 Manicure and Pedicure Station Exhaust System

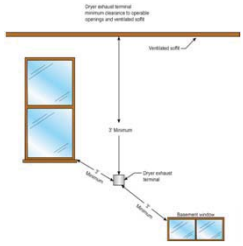
2021 CODE: 502.20 Manicure and pedicure stations. (Text remains unchanged)

502.20.1 Operation. The exhaust system for manicure and pedicure stations shall have controls that operate the system continuously when the space is occupied.

74

504.4.1 Termination Location for Dryer Exhaust

2021 CODE: 504.4.1 Termination location. Exhaust duct terminations shall be in accordance with the dryer manufacturer's installation instructions. Where the manufacturer's instructions do not specify a termination location, the exhaust duct shall terminate not less than 3 feet (914 mm) in any direction from openings into buildings including openings in ventilated soffits.



75

504.6 Booster fans prohibited

2021 CODE: 504.6 Booster fans prohibited. Domestic booster fans shall not be installed in dryer exhaust systems.

Dryer exhaust duct power ventilator listed and labeled to UL 705 for use in dryer exhaust duct systems.

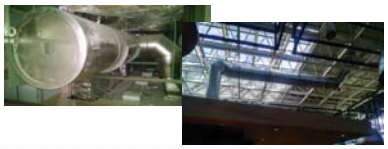
Booster fan

76

506.3.7 Factory-Built Grease Duct Slope

2021 CODE: 506.3.7 Prevention of grease accumulation in grease ducts.
(Text remains unchanged)

Exception: Factory-built grease ducts shall be installed at a slope that is in accordance with the listing and manufacturer's installation instructions.



77

506.3.9 Grease duct horizontal cleanouts

2021 CODE: 506.3.9 Grease duct horizontal cleanouts. Cleanouts serving horizontal sections of grease ducts shall:

1. to 5. "Unchanged"
6. ~~Shall be~~ Be located at grease reservoirs.
7. Be located within 3 feet of horizontal discharge fans.

78

507.1 Smoker Ovens with Integral Exhaust

2021 CODE: 507.1 General. (Text remains unchanged)

Exceptions:

1. to 3. "Unchanged"
4. Smoker ovens with integral exhaust systems, provided that the appliance is installed in accordance with the manufacturer's installation instructions, is listed and tested for the application and complies with Chapter 5.

Smoker oven with integral exhaust

79

514.2 Energy Recovery Ventilation Systems

2021 CODE: 514.2 Prohibited applications.
Energy recovery ventilation systems shall not be used in the following systems:

1. to 3. "Unchanged"
4. Commercial kitchen exhaust systems serving Type I ~~or Type II~~ hoods.
5. "Unchanged"

Exception: "Unchanged"

80

Chapter 6

Duct Systems

81

602.2.1.8 Pipe and Duct Insulation within Plenums

2021 CODE: 602.2.1.8 Pipe and duct insulation within plenums. Pipe and duct insulation contained within plenums, including insulation adhesives, shall have a flame spread index of not more than 25 and a smoke developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723, using the specimen preparation and mounting procedures of ASTM E2231. Pipe and duct insulation shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C). Pipe and duct insulation shall be listed and labeled. Pipe and duct insulation shall not be used to reduce the maximum flame spread and smoke-developed indices except where the pipe or duct and its related insulation, coatings and adhesives are tested as a composite assembly in accordance with Section 602.2.1.7. Pipe insulation

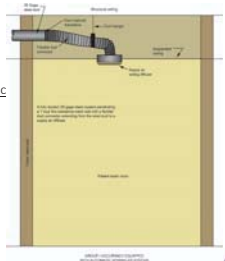
82

607.5.2 Duct Penetrations of Fire Barriers

2021 CODE: 607.5.2 Fire barriers; Exception 3:
"New Text Added"

Flexible air connectors shall be permitted in a fully ducted system, limited to the following installations.

3.1. Nonmetallic flexible connections that connect a duc to an air handling unit or equipment located within a mechanical room in accordance with Section 603.9.
3.2. Nonmetallic flexible air connectors in accordance with Section 603.6.2 that connect an overhead metal duct to a ceiling diffuser where the metal duct and ceiling diffuser are located within the same room.

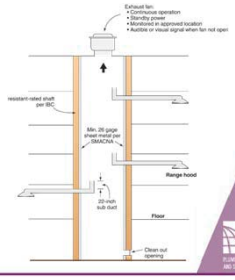


83

607.5.5 Subducts Penetrating Shaft Enclosures

2021 CODE: 607.5.5 Shaft enclosures.; Exception 1.1:
"Language modified"

1.1 Steel exhaust subducts having a wall thickness of not less than 0.0187 inch (0.4712 mm) extend not less than 22 inches (559 mm) vertically in exhaust shafts and an exhaust fan is installed at the upper terminus of the shaft that is powered continuously, in accordance with Section 909.11 of the International Building Code, so as to maintain a continuous airflow upward to the outdoors. ~~provided that there is a continuous airflow upward to the outdoors.~~



84

608.1 Balancing

2021 CODE: **608.1 Balancing.** Air distribution, ventilation and exhaust systems shall be provided with means to adjust the system to achieve the design airflow rates and shall be balanced by an approved method. Ventilation air distribution shall be balanced by an approved method and such balancing shall verify that the air distribution system is capab

85

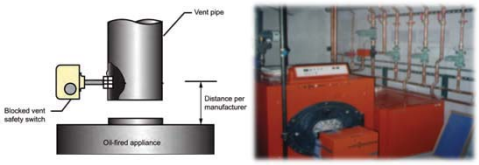
Chapter 8

Chimneys and Vents

86

801.21 Blocked Vent Switch for Oil-Fired Appliances

2021 CODE: **801.21 Blocked vent switch.** Oil-fired appliances shall be equipped with a device that will stop burner operation in the event that the venting system is obstructed. Such device shall have a manual reset, and shall be installed in accordance with the manufacturer's instructions.



87

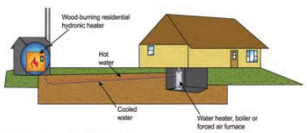
Chapter 9

Specific Appliances, Fireplaces and Solid-Fuel-burning Equipment

88

905.1 Wood-Burning Residential Hydronic Heaters

2021 CODE: **905.1 General.** Fireplace stoves and solid-fuel-type room heaters shall be listed and labeled and shall be installed in accordance with the conditions of the listing. Fireplace stoves shall be tested in accordance with UL 737. Solid-fuel-type room heaters shall be tested in accordance with UL 1482. Fireplace inserts intended for installation in fireplaces shall be listed and labeled in accordance with the requirements of UL 1482 and shall be installed in accordance with the manufacturer's instructions. New wood-burning residential hydronic heaters shall be EPA certified.

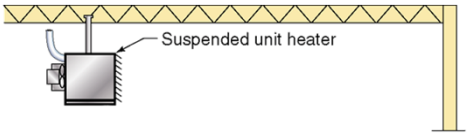


Wood-burning residential hydronic heater

89

Section 920 Unit Heaters

2021 CODE: **920.4 Prohibited Uses.** In Group I-2 and ambulatory care facilities, suspended-type unit heaters are prohibited in corridors, exit access stairways and ramps, exit stairways and ramps and patient sleeping areas.



90

929 Unvented Alcohol Fuel Burning Decorative Appliances

2021 CODE: SECTION 929, UNVENTED ALCOHOL FUEL-BURNING DECORATIVE APPLIANCES

929.1 General. Unvented alcohol fuel-burning decorative appliances shall be listed and labeled in accordance with UL 1370 and shall be installed in accordance with the conditions of the listing, manufacturer's instructions and Chapter 3.

Photo courtesy of EcoSmart Fire

Unvented alcohol fuel-burning decorative appliance

91

Chapter 11

Refrigeration

92

1101 General

2021 CODE: **1101.1 Scope.** This chapter shall govern the design, installation, construction and repair of refrigeration systems that vaporize and liquefy a fluid during the refrigerating cycle. ~~Refrigerant piping design and installation, including pressure vessels and pressure relief devices, shall conform to this code.~~ Permanently installed refrigerant storage systems and other components shall be considered as part of the refrigeration system to which they are attached.

1101.1.1 Refrigerants other than ammonia. Refrigerant piping design and installation, including pressure vessels and pressure relief devices, for systems containing a refrigerant other than ammonia shall comply with this chapter and ASHRAE 15.

93

1101 General

2021 CODE: **1101.1.2 Ammonia refrigerant.** Refrigeration systems using ammonia as the refrigerant shall comply with IIAR 2, IIAR 3, IIAR 4 and IIAR 5, and shall not be required to comply with this chapter.

94

1101 General

Table 1101.2
Factory-built equipment and appliances

EQUIPMENT	STANDARDS
Refrigeration fittings, including press-connect, flared, and threaded	UL 109 and UL 207
Air conditioning equipment	UL 1995 or UL/CSA 60335-2-40
Packaged terminal air conditioners and heat pumps	UL 484 or UL/CSA 60335-2-40
Split-system air conditioners and heat pumps	UL 1995 or UL/CSA 60335-2-40
Dehumidifiers	UL 474 or UL/CSA 60335-2-40
Unit coolers	UL 412 or UL/CSA 60335-2-89
Commercial refrigerators, freezers, beverage coolers, and walk-in coolers	UL 471 or UL/CSA 60335-2-89
Refrigerating units and walk-in coolers	UL 427 or UL 60335-2-89
Refrigerant-containing components and accessories	UL 207

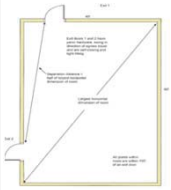
95

Table 1103.1 Refrigerant Classification, Amount, and OEL

Chemical Refrigerant	Formula	Chemical Name of Blend	Refrigerant Classification	Amount of Refrigerant Per Occupied Space				[F] Degrees of Hazard
				Lbs/1000 ft³	ppm	g/m³	OEL	
R-407G	zeotrope	R-32/125/134a (2.5/2.5/95.0)	A1	13	52,000	210	1,000	-
R-407H	zeotrope	R-32/125/134a (32.5/15.0/52.5)	A1	19	92,000	300	1,000	-
R-449B	zeotrope	R-32/125/1234yf/134a (25.2/24.3/23.2/27.3)	A1	23	110,000	370	850	-
R-449C	zeotrope	R-32/125/1234yf/134a (20.0/20.0/31.0/29.0)	A1	23	98,000	360	800	-
R-452A	zeotrope	R-32/125/1234yf (11.0/59.0/30.0)	A1	27	~~100,000~~ 10,000	440	780	-
R-452B	zeotrope	R-32/125/1234yf (67.0/7.0/26.0)	A2[L]	23	30,000	360	870	-

96

1105.9 Machinery Room Means of Egress



2021 CODE: **1105.9 Means of egress.** Machinery rooms larger than 1000 square feet (93 m2) in area shall have not less than two exits or exit access doorways. Where two exit access doorways are required, one such doorway is permitted to be served by a fixed ladder or an alternating tread device. Exit access doorways shall be separated by a horizontal distance equal to or greater than one-half of the largest horizontal dimension of the room. All portions of machinery rooms shall be within 150 feet (45.7 m) of an exit or exit access doorway. An increase in exit travel distance is permitted where in accordance with Section 1017.1 of the International Building Code. Exit and exit access doorways shall swing in the direction of egress travel and shall be equipped with panic hardware, regardless of the occupant load served. Exit and exit access doorways shall be tight-fitting and self-closing.

97

Sections 1107 through 1110

2021 CODE:
Section 1107 ~~Refrigerant Piping~~ Piping Material
Section 1108 ~~Field Test~~ Joints and Connections
Section 1109 Refrigerant Pipe Installation
Section 1110 Refrigerant Piping System Test

98

Chapter 12

Hydronic Piping

99

Section 1203 Joints and Connections

2021 CODE: **1203.7 CPVC plastic pipe.** Joints between CPVC plastic pipe or fittings shall be mechanical, solvent- cemented or threaded joints conforming to Section 1203.3.

100

Chapter 13

Fuel Oil Piping and Storage

101

Section 1303 Joints and Connections

2021 CODE: **1303.3 Joint preparation and installation.** Where required by Sections 1303.4 through 1303.9, the preparation and installation of brazed, mechanical, threaded, press-connect and welded joints shall comply with Sections 1303.3.1 through ~~1303.3.4.~~1303.3.5.

1303.3.2 Mechanical joints. Mechanical joints shall be installed in accordance with the manufacturer's instructions. ~~Press-connect joints shall conform to one of the standards listed in Table 1302.3.~~

1303.3.5 Press-connect joints. Press-connect joints shall be installed in accordance with the manufacturer's instructions and shall conform to one of the standards listed in Table 1302.3.

1303.4 Copper or copper-alloy pipe. Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, threaded, press-connect or welded joints complying with Section 1303.3.

102

Discussion Activity

103

2021 International Fuel Gas Code®, IFGC®

Based on the 2021 International Fuel Gas Code®

104

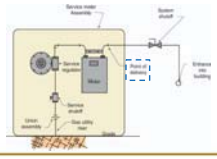
Chapter 2

Definitions

105

Section 202
Definition of Point of Delivery

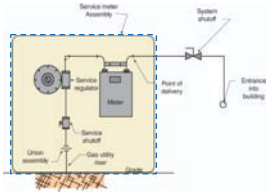
2021 CODE: **POINT OF DELIVERY.** For natural gas systems, the point of delivery is the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where a meter is not provided. Where a system shutoff valve is provided ~~at~~ after the outlet of the service meter assembly, such valve shall be considered to be downstream of the point of delivery. For undiluted liquefied petroleum gas systems, the point of delivery shall be considered to be the outlet of the service pressure regulator, exclusive of line gas regulators, in the system.



106

Section 202
Definitions Related to Point of Delivery

2021 CODE: **SERVICE METER ASSEMBLY.** The meter, valve, regulator, piping, fittings and equipment installed by the service gas supplier before the point of delivery.



107

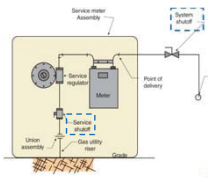
Section 202
Definitions Related to Point of Delivery

2021 CODE:

SYSTEM SHUTOFF. A valve installed after the point of delivery to shut off the entire piping system.

VALVE. A device used in piping to control the gas supply to any section of a system of piping or to an appliance.

SERVICE SHUTOFF. A valve, installed by the serving gas supplier between the ~~service meter or~~ source of supply and the point of delivery ~~customer piping system~~, to shut off the entire piping system.



108

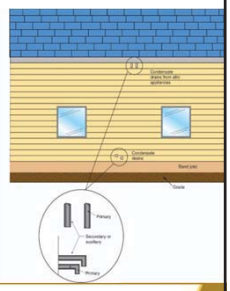
Chapter 3

General Regulations

109

307.2 Fuel-Burning Appliances (Concealed Condensate Piping)

2021 CODE: **307.2 Fuel-burning appliances.** Liquid combustion by-products of condensing appliances shall be collected and discharged to an approved plumbing fixture or disposal area in accordance with the manufacturer's instructions. Condensate piping shall be of approved corrosion-resistant material and shall be not smaller than the drain connection on the appliance. Such piping shall maintain a minimum slope in the direction of discharge of not less than one-eighth unit vertical in 12 units horizontal (1-percent slope). The termination of concealed condensate piping shall be marked to indicate whether the piping is connected to the primary drain or to the secondary drain.



110

Chapter 4

Gas Piping Installations

111

402.7 Maximum Operating Pressure (Press-Connect Joint)

2021 CODE: **402.7 Maximum operating pressure.** The maximum operating pressure for piping systems located inside buildings shall not exceed 5 pounds per square inch gauge (psig) (34 kPa gauge) except where one or more of the following conditions are met:

1. The piping joints are welded or brazed.

2. The piping is joined by fittings listed to ANSI LC-4/CSA 6.32 and installed in accordance with the manufacturer's instructions.

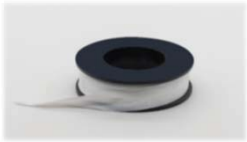
(Items 3 through 8 are unchanged)

The code now recognizes press-connect joints as suitable for high pressure (over 5 psig) applications indoors.

112

403.8.3 Threaded Joint Sealing

2021 CODE: **403.8.3 Threaded joint ~~compounds~~ sealing.** Threaded joints shall be made using a thread joint sealing material. Thread joint sealing materials ~~compounds~~ shall be nonhardening and shall be resistant to the ~~action of liquefied petroleum gas or to any other~~ chemical constituents of the gases to be conducted through the piping. Thread joint sealing materials shall be compatible with the pipe and fitting materials on which the sealing materials are used.



113

404.5 Fittings in Concealed Locations

- 2021 CODE: **404.5 Fittings in concealed locations.** Fittings installed in concealed locations shall be limited to the following types:
- 1. Threaded elbows, tees, couplings, plugs and caps.
- 2. Brazed fittings.
- 3. Welded fittings.
- 4. Fittings listed to ANSI LC-1/CSA 6.26 or ANSI LC-4/CSA 6.32.

Caps and plugs are permitted to be concealed

114

Chapter 5

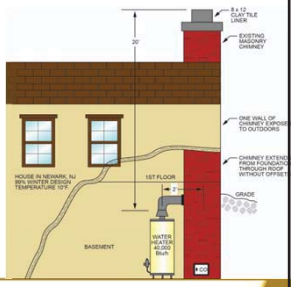
Chimney and Vents

115

503.5.6.1 Chimney Lining

2021 CODE: **503.5.6.1 Chimney lining.** Chimneys shall be lined in accordance with NFPA 211.

~~**Exception:** Where an existing chimney complies with Sections 503.5.6 through 503.5.6.3 and its sizing is in accordance with Section 503.5.5, its continued use shall be allowed where the appliance vented by such chimney is replaced by an appliance of similar type, input rating and efficiency.~~



116

503.8 Venting System Terminal Clearances

2021 CODE: **503.8 Venting system ~~termination location~~ terminal clearances.** The clearances for through-the-wall direct-vent and nondirect-vent terminals shall be in accordance with Table 503.8 and Figure 503.8.

Exception: The clearances in Table 503.8 shall not apply to the combustion air intake of a direct-vent appliance.

All other section 503.8 text deleted; Table 503.8 replaced, as shown.

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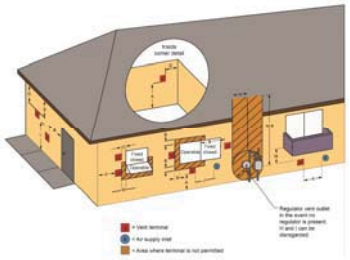
FIGURE 503.8
Through-the-wall Vent Terminal Clearance



118

503.10.7 Vent Connector Junctions

2021 CODE: **503.10.7 Connector junctions.** Where vent connectors are joined together, the connection shall be made with a tee or wye fitting.

119

Chapter 6

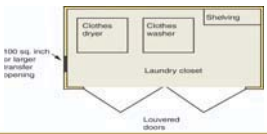
Specific Appliances

120

614.7 Makeup Air (Clothes Dryer)

2021 CODE: **614.7 Makeup air.** Installations exhausting more than 200 cfm (0.09 m3/s) shall be provided with makeup air. ~~Where a closet is designed for the installation of a clothes dryer, an opening having an area of not less than 100 square inches (645 mm2) for makeup air shall be provided in the closet enclosure, or makeup air shall be provided by other approved means.~~

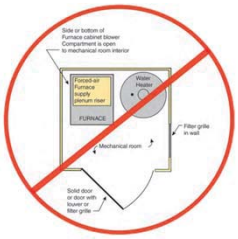
614.7.1 Closet Installation. Where a closet is designed for the installation of a clothes dryer, an opening having an area of not less than 100 square inches (645 mm2) for makeup air shall be provided in the closet enclosure, or makeup air shall be provided by other approved means.



121

618.6 Return Air from Mechanical Room

2021 CODE: **618.6 Furnace plenums and air ducts.** Where a furnace is installed so that supply ducts carry air circulated by the furnace to areas outside of the space containing the furnace, the return air shall be handled by a duct(s) sealed to the furnace casing and terminating outside of the space containing the furnace. Return air shall not be taken from the mechanical room containing the furnace.



122

623.2 Commercial Cooking Appliances

2021 CODE: **623.2 Prohibited location.** Cooking appliances designed, tested, listed and labeled for use in commercial occupancies shall not be installed within dwelling units or within any area where domestic cooking operations occur.

~~Exceptions~~ **Exception:**

1. Appliances that are also listed as domestic cooking appliances.
2. ~~Where the installation is designed by a licensed Professional Engineer, in compliance with the manufacturer's installation instructions.~~

123

Discussion Activity

124

Thank you for participating

To schedule a seminar, contact:

The ICC Training & Education Department
1-888-ICC-SAFE (422-7233) Ext. 33821
or
E-mail: Learn@iccsafe.org

125

Copyright Materials

126

File Attachments for Item:

EC-8 An Overview of Changes from ACI 318-14 to ACI 318-19 (ICC)

All certifications (2 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: An Overview of Changes from ACI 318-14 to ACI 318-19

Course instructor: Dr. S. K. Ghosh

Course description: ACI 318-19, Building Code Requirements for Structural Concrete is the updated edition from the 2014 edition. Referenced in the 2021 International Building Code, the ACI 318, 2019 edition contains significant changes from the 2014 edition in areas such as structural ~~integrity provisions for one-way Slabs, streamlined provisions for two-way slab design, modified shear design provisions for non~~-prestressed beams and one-way slabs, acceptance of the use of high-strength reinforcing bars, strength reduction factor modifications as impacted by the use of high-strength reinforcing bars up to Grade 100, strength evaluation of existing buildings and numerous other changes.

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: May 1, 2023 Tampa, FL

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

x Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

An Overview of Changes from ACI 318-14 to ACI 318-19

Description

ACI 318-19, Building Code Requirements for Structural Concrete is the updated edition from the 2014 edition. Referenced in the 2021 International Building Code, the ACI 318, 2019 edition contains significant changes from the 2014 edition in areas such as structural integrity provisions for one-way Slabs, streamlined provisions for two-way slab design, modified shear design provisions for non-prestressed beams and one-way slabs, acceptance of the use of high-strength reinforcing bars, strength reduction factor modifications as impacted by the use of high-strength reinforcing bars up to Grade 100, strength evaluation of existing buildings and numerous other changes. The presentation will provide a general overview of select changes and will then go into an in-depth discussion on some of the significant changes. Experienced as well as beginner structural engineers and building officials will benefit from this unique presentation.

Learning Objectives

1. Get an overview of ACI 318-19.
2. Learn about significant changes in ACI 318-19 from ACI 318-14.
3. Learn the implications of the changes in design.
4. Discover the challenges a practicing engineer may face following ACI 318-19.

Outline of Seminar **(2 hours = 120 minutes)**

1:00 PM – 3:00 PM

I. An Overview of Changes from ACI 318-14 to ACI 318-19 (120 minutes)
   I. Highlights of the changes from ACI 318-14 to 318-19
   II. Chapter by Chapter review of the non-seismic changes. (ACI 318-19 excluding Chapter 18)
   III. Discussion

Please allow for breaks at natural intervals

Instructor Bio: Dr. S.K. Ghosh, PhD

Dr. Ghosh is a former member of the Boards of Direction of ACI, the Earthquake Engineering Research Institute (EERI) and BSSC (Building Seismic Safety Council). He is a member of the Board of Governors of ASCE's Structural Engineering Institute. Ghosh has long been a provider of continuing education related to structural provisions of building codes to the structural engineering profession and the code enforcement community. His books and other publications on structural design are widely used by those in design practice. In addition to authoring over 200 papers and books, Dr. Ghosh has investigated and reported on structural performance in most recent earthquakes. Among his many awards, on the 50th anniversary of the Precast/Prestressed Concrete Institute (PCI) in 2004, S. K. Ghosh was named one of fifty "Titans" of the U.S. Precast/Prestressed Concrete Industry. He was awarded ASCE's 2013 Walter P. Moore Jr. Award for his contributions towards improving the consistency, accuracy and clarity of structural codes and standards throughout the U.S. and abroad. Ghosh has a Bachelor of Engineering (BE) in civil engineering from the University of Calcutta, India, and a Master of Applied Science (MASc) and Doctor of Philosophy (Ph.D.) in structural engineering from the University of Waterloo, Ontario, Canada.

Significant Changes in ACI 318-19

S. K. Ghosh

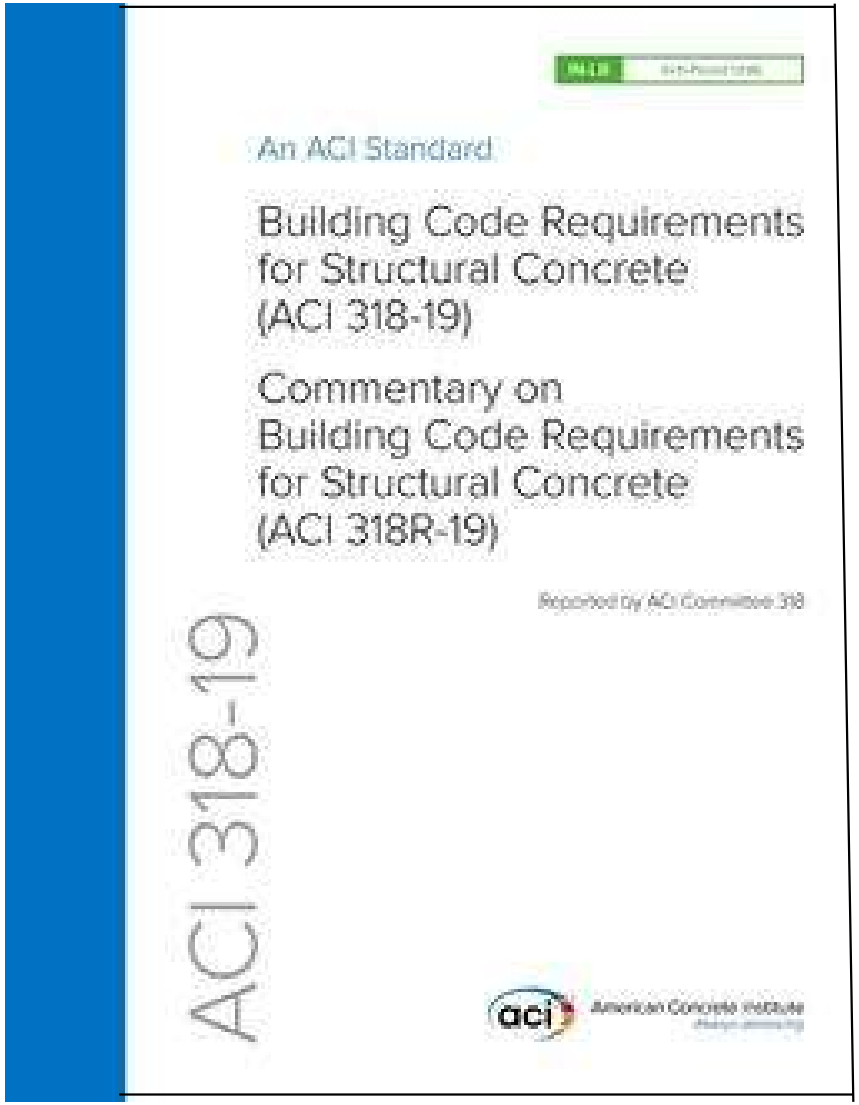
S. K. Ghosh Associates LLC

Palatine, IL

November 3, 2020

www.skghoshassociates.com

ACI 318-19


An ACI Standard
Building Code Requirements for Structural Concrete (ACI 318-19)
Commentary on Building Code Requirements for Structural Concrete (ACI 318R-19)
ACI 318-19
aci
American Concrete Institute

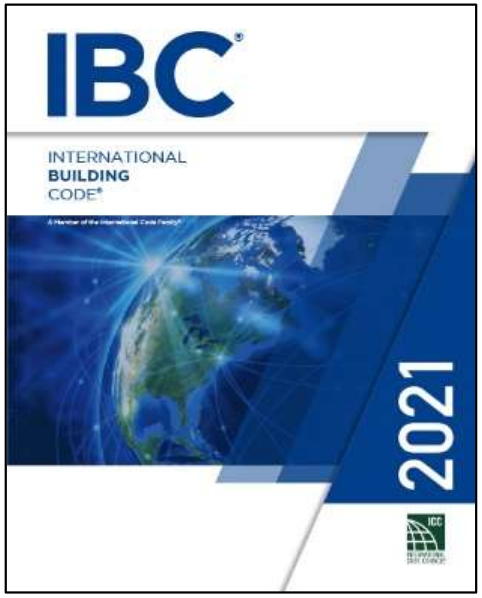
ACI 318-19

- A large number of substantive changes of far-reaching consequence
- Will require significant learning and adjustment on the part of the practitioner

ACI 318-19

ACI 318-19 is the referenced standard for concrete design and construction in

- The 2021 IBC
- ASCE 7-22



The 2021 IBC has been and is being adopted by major jurisdictions around the country.

Some Highlights

- Introduction of high-strength reinforcement
- Modification of straight bar development length provisions
- Modification of hooked/headed bar development length provisions
- Simplified shear provisions for nonprestressed beams and slabs
- Recognition of size effect on shear strength contributed by concrete

Some Highlights

- Introduction of screw anchors and shear lugs
- Introduction of shotcrete provisions
- Shear strength equations for ordinary and special shear walls coordinated
- Extensive additions to the foundations chapter, which now covers deep foundations
- Highly important changes to the design of special shear walls (Not Discussed)
- Other important changes in seismic detailing requirements (Not Discussed)

Chapter 1—General

1.7 Licensed Design Professional

[MODIFIED]

1.7.1 All references in this Code to the licensed design professional shall be understood to mean the ~~person who is licensed and responsible for, and in charge of, the structural design or inspection~~ engineer in either 1.7.1.1 or 1.7.1.2.

1.7.1.1 The licensed design professional responsible for, and in charge of, the structural design work.

1.7 Licensed Design Professional

1.7.1.2 A specialty engineer to whom a specific portion of the structural design work has been delegated subject to the condition of (a) and (b)

(a) The authority of the specialty engineer shall be explicitly limited to the delegated design work.

(b) The portion of design work delegated shall be well defined such that responsibilities and obligations of the parties are apparent.

Chapter 2—Notation and Terminology

Chapter 3—Referenced Standards

Chapter 4—Structural System Requirements

4.2 Materials – Shotcrete

- **4.2.1.1** Design properties of shotcrete shall conform to the requirements for concrete except as modified by provisions of the Code.
- Sections with shotcrete provisions added to ACI 318-19.

4.4.6 Seismic-Force-Resisting System

- Authority having jurisdiction replaced with Building official.
- **4.4.6.7** Design verification of earthquake-resistant concrete structures using nonlinear response history analysis shall be in accordance with Appendix A.

Chapter 5—Loads

Chapter 6—Structural Analysis

6.2.4.1 Two-Way Slabs

6.2.4.1 Two-way slabs shall be permitted to be analyzed for gravity loads in accordance with (a) or (b):

(a) Direct design method for nonprestressed slabs ~~in 8.10~~

(b) Equivalent frame method for nonprestressed and prestressed slabs ~~in 8.11~~

R6.2.4.1 Two-Way Slabs

R6.2.4.1 Code editions from 1971 to 2014 contained provisions for use of the direct design method and the equivalent frame method. These methods are well-established and are covered in available texts. These provisions for gravity load analysis of two-way slabs have been removed from the Code because they are considered to be only two of several analysis methods currently used for the design of two-way slabs. The direct design method and the equivalent frame method of the 2014 Code, however, may still be used for the analysis of two-way slabs for gravity loads.

6.7 Linear Elastic Second-Order Analysis

6.7 – Linear elastic second-order analysis

ACI 318-19 provides clarification on elastic vs inelastic analysis and first-order vs second-order analysis. It presents 4 methods:

- Linear elastic first-order analysis
- Linear elastic second-order analysis
- Inelastic first-order analysis
- Inelastic second-order analysis

6.7 Linear Elastic Second-Order Analysis

- First-order analysis: initial undeformed shape of the structure is considered.
- Second-order analysis: actual deformed shape of the structure should be considered.

Chapter 7—One-Way Slabs

7.3.3 Reinforcement Strain Limit in Nonprestressed Slabs.

7.3.3.1 ~~For nonprestressed slabs, ε_t shall be at least 0.004~~ Nonprestressed slabs shall be tension-controlled in accordance with Table 21.2.2.

This applies to two-way slabs and beams as well.

Table 21.2.2 provides ε_t limits for tension-controlled sections : $\varepsilon_t \geq \varepsilon_{ty} + 0.003$

Compression Controlled Strain Limit, ε_{ty}

21.2.2.1 For deformed reinforcement, ε_{ty} shall be f_y/E_s. For Grade 60 deformed reinforcement, it shall be permitted to take ε_{ty} equal to 0.002.

21.2.2.2 For all prestressed reinforcement, ε_{ty} shall be taken as 0.002.

7.6 Reinforcement Limits

7.6.1.1 Minimum area of flexural reinforcement, $A_{s,min}$, of $0.0018A_g$ shall be provided ~~in accordance with Table 7.6.1.1~~.

Table 7.6.1.1—$A_{s,min}$ for nonprestressed one-way slabs

Reinforcement type	f_y, psi	$A_{s,min}$	
Deformed bars	$< 60{,}000$	$0.0020A_g$	
Deformed bars or welded wire reinforcement	$\geq 60{,}000$	Greater of:	$\frac{0.0018 \times 60{,}000}{f_y} A_g$
			$0.0014A_g$

24.4 Shrinkage and Temperature Reinforcement

R24.4.3.2 Previous editions of the Code permitted a reduction in shrinkage and temperature reinforcement for reinforcement with yield strength greater than 60,000 psi. However, the mechanics of cracking suggest that increased yield strength provides no benefit for the control of cracking.

7.7.7 Structural Integrity Reinforcement in Cast-in-Place One-Way Slabs [NEW]

Reason: To make structural integrity requirements for one-way cast-in-place slabs consistent with those for beams.

7.7.7 Structural integrity reinforcement in cast-in-place one-way slabs

7.7.7.1 Longitudinal structural integrity reinforcement consisting of at least one-quarter of the maximum positive moment reinforcement shall be continuous.

7.7.7 Structural Integrity Reinforcement in Cast-in-Place One-Way Slabs [NEW]

7.7.7.2 Longitudinal structural integrity reinforcement at noncontinuous supports shall be anchored to develop f_y at the face of the support.

7.7.7.3 If splices are necessary in continuous structural integrity reinforcement, the reinforcement shall be spliced near supports. Splices shall be mechanical or welded in accordance with 25.5.7 or Class B tension lap splices in accordance with 25.5.2.

Chapter 8—Two-Way Slabs

Table 8.3.1.1 Minimum Thickness

- The table for minimum thickness of nonprestressed two-way slabs without interior beams has changed.
- Values for f_y=75,000 psi are replaced by values for f_y=80,000 psi.
- For f_y exceeding 80,000 psi, the calculated deflection limits in 8.3.2 [Table 24.2.2] shall be satisfied assuming a reduced modulus of rupture f_r=5$\sqrt{f_c'}$.

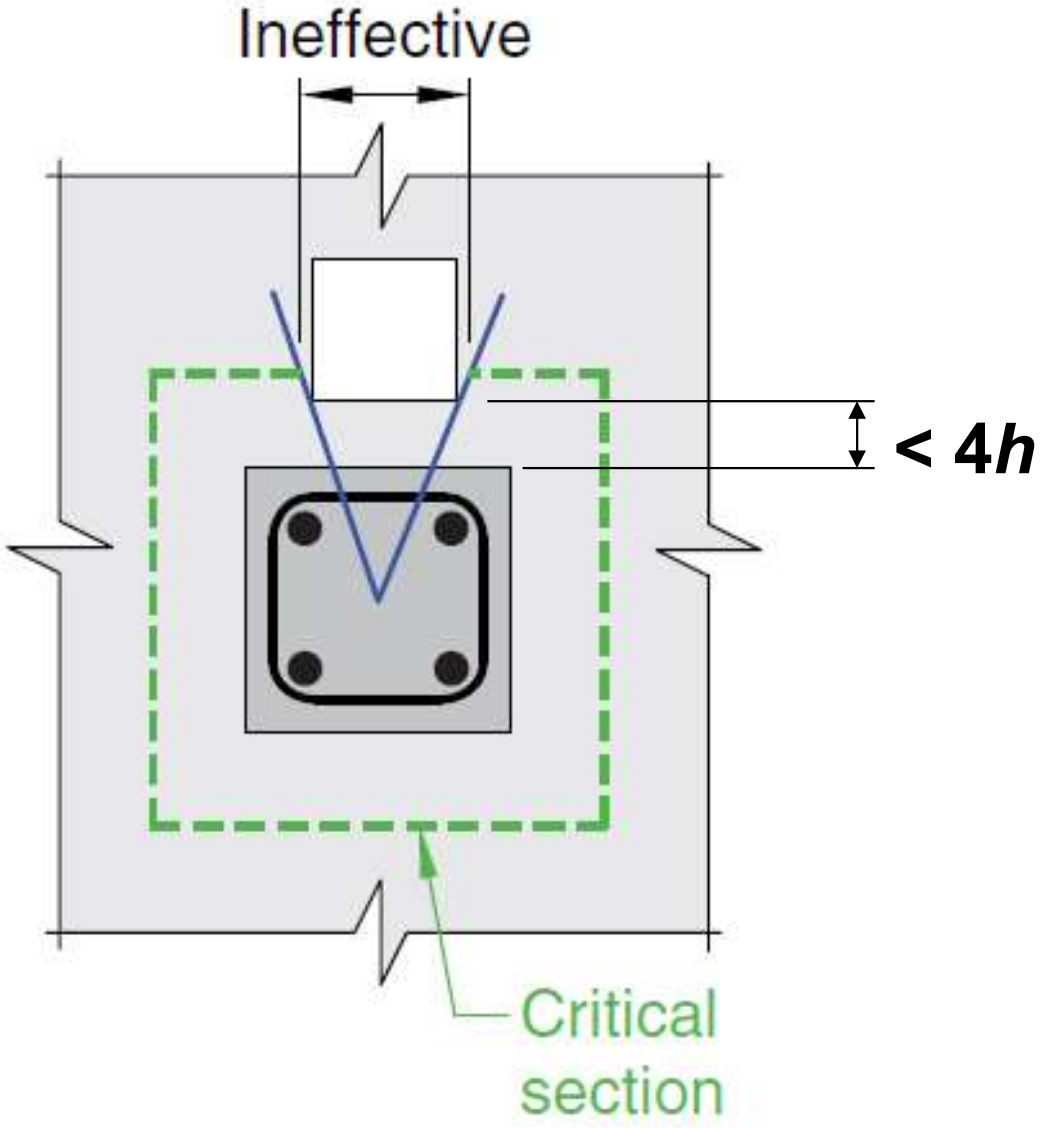
8.5.4.2 Openings

8.5.4.2 (d) has been modified to reduce the distance at which there is an effect of openings on shear strength from *10h* to *4h*.

(d) If an opening is located ~~within a column strip~~ or closer than 4*h* ~~10*h*~~ from the periphery of a column, concentrated load, or reaction area, 22.6.4.3 ~~for slabs without shearheads or 22.6.9.9 for slabs with shearheads~~ shall be satisfied.

Critical Section for Two-Way Shear Strength

22.6.4.3



8.6.1 Minimum Flexural Reinforcement in Nonprestressed Slabs

- **Table 8.6.1.1** removed and replaced with requirement that minimum area of flexural reinforcement $A_{s,min}$ be $0.0018A_g$ or as calculated by 8.6.1.2.
- New: **8.6.1.2** If $v_{uv} > \phi 2\lambda_s\lambda\sqrt{f_c'}$ on the critical section for two-way shear surrounding a column, concentrated load, or reaction area, $A_{s,min}$, provided over the width b_{slab}, shall satisfy Eq. (8.6.1.2)

8.6.1 Minimum Flexural Reinforcement in Nonprestressed Slabs

Eq. 8.6.1.2

$$A_{s,min} = \frac{5 v_{uv} b_{slab} b_o}{\phi \alpha_s f_y}$$

α_s is 40 for interior columns, 30 for edge columns, and 20 for corner columns.

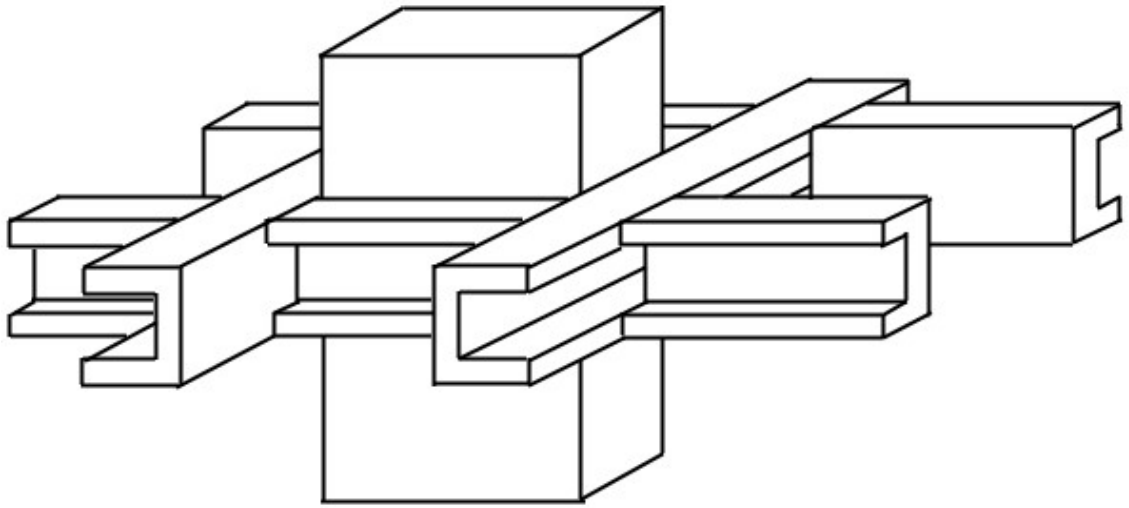
- Commentary with explanation and background added.

Shearheads

All references to shearheads are removed from Chapter 8 because

22.6.9 *Design provisions for two-way members with shearheads*

is removed from ACI 318-19.



Chapter 9—Beams

R9.7.6.2.1 Hanger Reinforcement

R9.7.6.2.1 If a reinforced concrete beam is cast monolithically with a supporting beam and intersects one or both side faces of a supporting beam, the soffit of the supporting beam may be subject to premature failure unless additional transverse reinforcement, commonly referred to as hanger reinforcement, is provided (Mattock and Shen 1992). The hanger reinforcement (Figure R9.7.6), placed in addition to other transverse reinforcement, is provided to transfer shear from the end of the supported beam.

R9.7.6.2.1 Hanger Reinforcement

R9.7.6.2.1 (Contd.) Research indicates that if the bottom of the supported beam is at or above middepth of the supporting beam or if the factored shear transferred from the supported beam is less than $3\sqrt{f'_c}b_w d$, hanger reinforcement is not required.

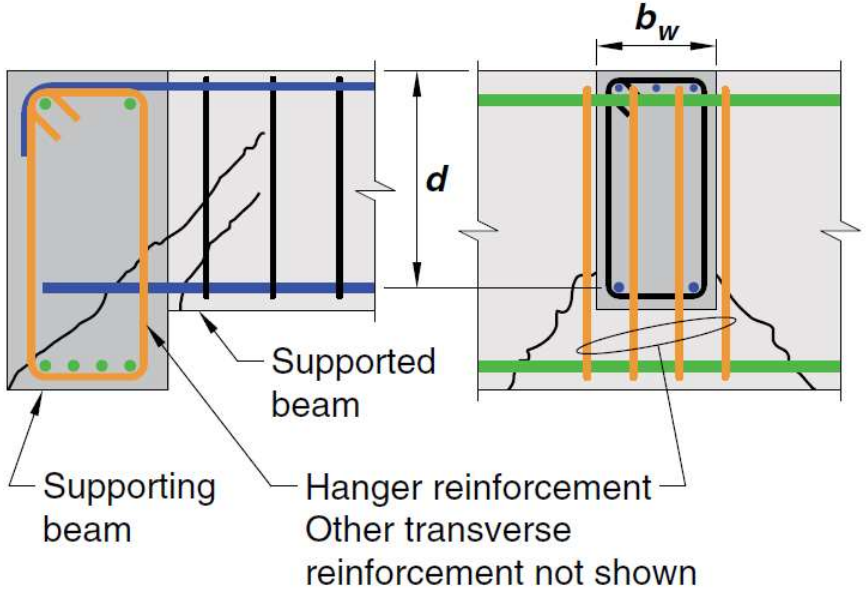


Fig. R9.7.6.2.1—Hanger reinforcement for shear transfer.

9.7.6 Transverse Reinforcement

9.7.6.2.2 Maximum spacing for shear reinforcement across the beam width for wide beams added to improve shear behavior of wide beams and one-way slabs.

Table 9.7.6.2.2 Maximum spacing of legs of shear reinforcement

Required V_s ~~$V_{s,required}$~~		Maximum s, in.			
		Nonprestressed beam		Prestressed beam	
		Along length	Across width	Along length	Across width
$\le 4\sqrt{f'_c}b_w d$	Lesser of:	$d/2$	d	$3h/4$	$3h/2$
		24 in.			
$> 4\sqrt{f'_c}b_w d$	Lesser of:	$d/4$	$d/2$	$3h/8$	$3h/4$
		12 in.			

Chapter 10—Columns

Composite Column Requirements Removed

- Removed composite column requirements from:

  10.1.1, 10.2.1.2, 10.2.2, 10.3.1.6, R10.3.1.6, 10.5.2.2, R10.5.2.2, 10.6.1.2, R10.6.1.2, 10.7.3.2, 10.7.5.3.2, R10.7.5.3.2, 10.7.6.1.4, R10.7.6.1.4

- Reason: ACI 318-14 had minimal composite column provisions that are outdated and incomplete.

- Refers users to AISC 360

R10.1—Scope

R10.1.1 Composite structural steel-concrete columns are not covered in this chapter. Composite columns include both structural steel sections encased in reinforced concrete and hollow structural steel sections filled with concrete. Design provisions for such composite columns are covered in AISC 360.

Chapter 11—Walls

11.1 – Scope

- **11.1.4** Design of cantilever retaining walls shall be in accordance with ~~22.2 through 22.4, with minimum horizontal reinforcement in accordance with 11.6~~ Chapter 13.
- **11.1.6** Cast-in-place walls with insulating forms shall be permitted by this Code for use in one- or two-story buildings.

11.2.4 – Intersecting Elements

- **11.2.4.2** For cast-in-place walls having $P_u > 0.2 f_c' A_g$, the portion of the wall within the thickness of the floor system shall have specified compressive strength at least $0.8 f_c'$ of the wall.
- Reason: To include the effect of floor system concrete strength on wall axial strength.
- **R11.2.4.2** The 0.8 factor reflects reduced confinement in floor-wall joints compared with floor-column joints under gravity loads.

11.5.4 In-Plane Shear: Coordination of Shear Strength Equations

11.5.4.~~3~~ 2 V_n at any horizontal section shall not exceed ~~$10\sqrt{f_c'}hd$~~ $8\sqrt{f_c'}A_{cv}$.

11.5.4.4 3 V_n shall be calculated by:

~~$V_n = V_c + V_s$~~ ~~(11.5.4.4)~~

$$V_n = (\alpha_c \lambda \sqrt{f_c'} + \rho_t f_{yt}) A_{cv} \qquad (11.5.4.3)$$

where:

$\alpha_c = 3$ for $h_w/\ell_w \leq 1.5$

$\alpha_c = 2$ for $h_w/\ell_w \geq 2.0$

α_c varies linearly between 3 and 2 for $1.5 < h_w/\ell_w < 2.0$

11.5.4 In-Plane Shear: Coordination of Shear Strength Equations

11.5.4.5 4 ~~Unless a more detailed calculation is made in accordance with 11.5.4.6, V_e shall not exceed $2\sqrt{f_c'}hd$ for walls subject to axial compression or exceed the value given in 22.5.7 f~~For walls subject to a net axial tension, α_c in Eq. (11.5.4.3) shall be taken as:

$$\alpha_c = 2\left(1+\frac{N_u}{500A_g}\right) \geq 0.0 \qquad (11.5.4.4)$$

where N_u is negative for tension.

Chapter 12—Diaphragms

Chapter 13—Foundations

13.1 Scope

- Two items added in the scope for this chapter
  - Cantilever retaining walls
  - Counterfort and buttressed cantilever retaining walls
- Reason: To clarify design of the reinforced concrete components of retaining walls.

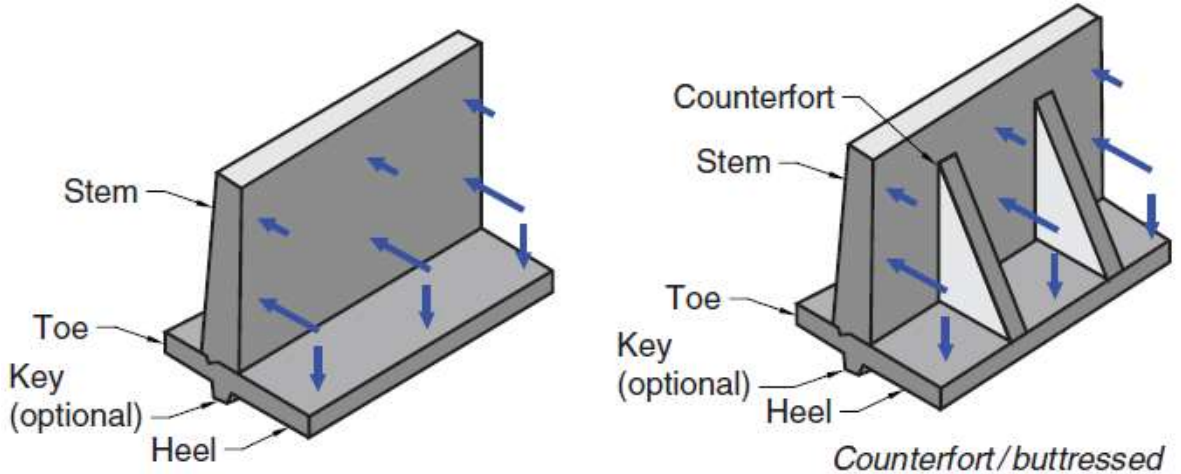


Fig. R13.1.1—Types of foundations.

13.2.6 Design Criteria

13.2.6.1 – ~~Foundations shall be proportioned to resist factored loads and induced reactions.~~ Foundations shall be proportioned for bearing effects, stability against overturning and sliding at the soil-foundation interface in accordance with the general building code.

13.2.6.2 – For one-way shallow foundations, two-way isolated footings, or two-way combined footings and mat foundations, it is permissible to neglect the size effect factor specified in 22.5 for one-way shear strength and 22.6 for two-way shear strength.

13.2.6 Design Criteria

13.2.6.3 – Foundation members shall be designed to resist factored loads and corresponding induced reactions except as permitted by 13.4.2 (allowable axial strength for deep foundations.)

13.4 Deep Foundations

R13.4.1.1

...

The 2019 edition of the Code contains provisions for the design of deep foundations. These provisions are based in part on similar provisions that were previously included in ASCE 7 and the IBC.

Chapter 14—Plain Concrete

Chapter 15—Beam-Column and Slab-Column Joints

15.2 General

15.2.1 Beam-column joints shall satisfy the detailing provisions of 15.3 and strength requirements of 15.4.

.

Chapter 16—Connection between Members

Required Strength for Bearing Connections

- ACI 318-14 provisions for restraint forces at bearing connections were given only for corbels and brackets.
- ACI 318-19 added 16.2.2.3 and 16.2.2.4 to include consideration of restraint forces at all bearing connections.

Chapter 17—Anchoring to Concrete

ACI 318-19

- Chapter 17 reorganized into member-based format
- Anchor inspection provisions transferred from Chapter 17 to Chapter 26
- New provisions for screw anchors
- New provisions for shear lugs

Reusing Post-Installed Mechanical Anchors Adhesive Anchors

17.1.3 The removal and resetting of post-installed mechanical anchors is prohibited.

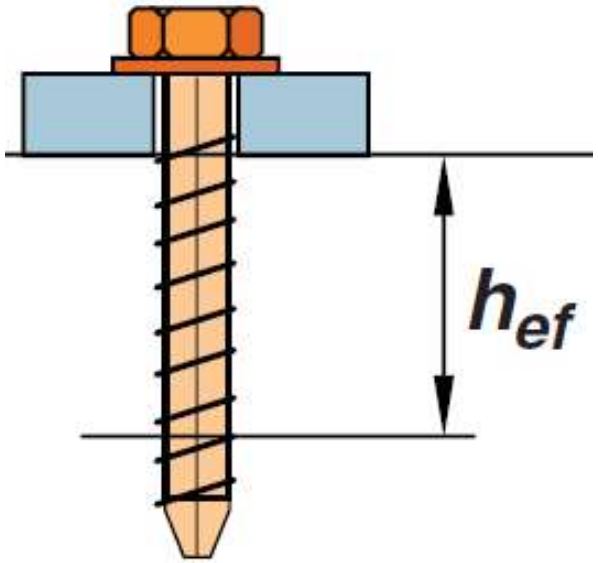
17.2.2 Adhesive anchors shall be installed in concrete having a minimum age of 21 days at time of anchor installation.

Other Changes
Reinforcement Used for Anchorage

17.1.6 Reinforcement used as part of an embedment shall have development length established in accordance with other parts of this Code. If reinforcement is used as anchorage, concrete breakout failure shall be considered. Alternatively, anchor reinforcement in accordance with 17.5.2.1 shall be provided.

Screw Anchors

- Design procedure is exactly the same as that for post-installed expansion or undercut anchors
- Separate values for various design parameters are provided.

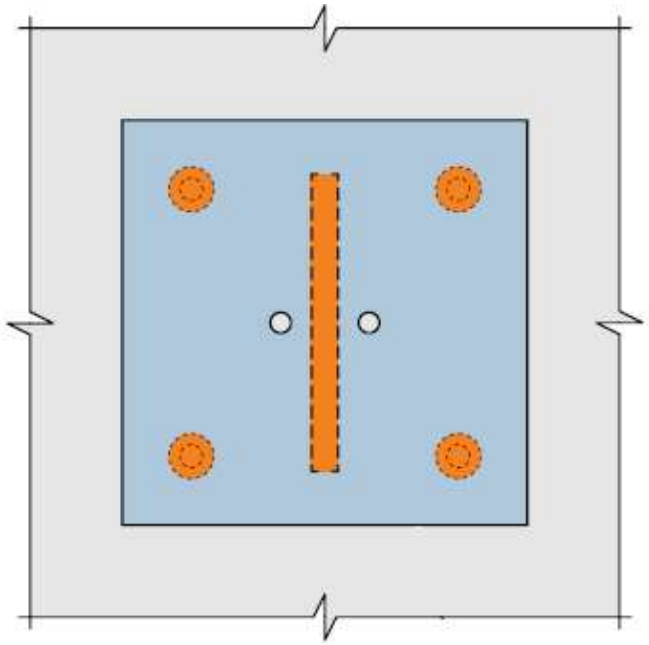


Screw Anchors

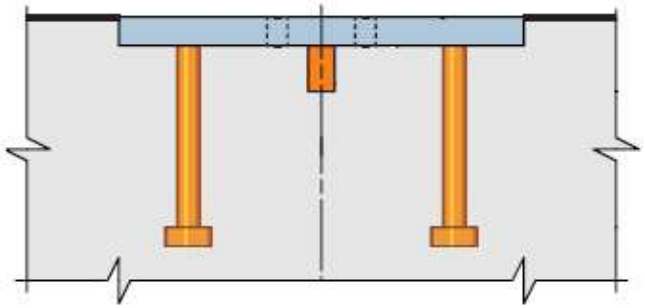
17.3.4 For screw anchors with embedment depths $5d_a \le h_{ef} \le 10d_a$, and $h_{ef} \ge 1.5$ in., concrete breakout strength requirements shall be considered satisfied by the design procedure of 17.6.2 [concrete breakout strength of anchors in tension] and 17.7.2 [concrete breakout strength of anchors in shear].

Shear Lugs

17.5.2.6 Attachments with shear lugs used to transfer structural loads shall satisfy the requirements of 17.11.



Plan



Elevation

Shear Lugs

- Steel plates welded to an attachment base plate
- Shear is transferred through direct bearing or concrete breakout
- Tension is transferred through separate anchor bolts/studs (minimum four anchors)

Chapter 18—Earthquake-Resistant Structures

NOT DISCUSSED

Chapter 19—Concrete: Design and Durability Requirements

19.2.1 Specified Compressive Strength

Table 19.2.1.1 is updated to add minimum specified concrete strength, f_c', for:

- Foundations (adopted from 2018 IBC Table 1808.8.1)
- Special structural walls with Grade 100 reinforcement
- Precast piles (adopted from 2018 IBC Table 1808.8.1)

19.2.1 Specified Compressive Strength

Minimum specified concrete strength, f_c', for foundations (adopted from 2018 IBC Table 1808.8.1)

Application	Minimum f_c', psi
Foundations for structures assigned to SDC A, B, or C	2500
Foundations for Residential and Utility use and occupancy classifications with stud bearing wall construction two stories or less assigned to SDC D, E, or F	2500
Foundations for structures assigned to SDC D, E, or F other than Residential and Utility use and occupancy classifications with stud bearing wall construction two stories or less	3000

19.2.1 Specified Compressive Strength

Minimum specified concrete strength, f_c', for special moment frames and special structural walls

Application	Minimum f_c', psi
Special moment frames Special structural walls with Grade 60 or 80 reinforcement	3000
Special structural walls with Grade 100 reinforcement	5000

19.2.1 Specified Compressive Strength

Minimum specified concrete strength, f_c', for precast piles (adopted from 2018 IBC Table 1808.8.1)

Application	Minimum f_c', psi
Precast-nonprestressed driven piles Drilled shafts	4000
Precast-prestressed driven piles	5000

19.2.2.2 Specification of E_c Based on Testing

19.2.2.2 It shall be permitted to specify E_c based upon testing of concrete mixtures to be used in the Work in accordance with (a) through (c):

(a) Specified E_c shall be used for proportioning concrete mixtures in accordance with 26.4.3.

(b) Testing to verify that the specified E_c has been achieved shall be conducted, and results shall be provided with the mixture submittal.

(c) Test age of measurement of E_c shall be 28 days or as indicated in the construction documents.

19.2.4.1 Determination of λ for Lightweight Concrete

New simplified option to determine λ based on equilibrium density of concrete.

Table 19.2.4.1(a)—Values of λ for lightweight concrete based on equilibrium density

w_c, lb/ft^3	λ	
≤ 100	0.75	(a)
100 < w_c ≤ 135	0.0075w_c ≤ 1.0	(b)
> 135	1.0	(c)

19.3 Concrete Durability Requirements: Exposure to Water

Exposure Class W0 is split into W0 and W1, and the old W1 is renamed W2

ACI 318-14 Table 19.3.1.1

In contact with water (W)	W0	Concrete dry in service Concrete in contact with water and low permeability is not required
	W1	Concrete in contact with water and low permeability is required

Renamed W2

New W1

19.3 Concrete Durability Requirements: Exposure to Water

Requirements for Exposure Category W are updated in Table 19.3.2.1

ACI 318-19 Table 19.3.2.1

Exposure Class	Maximum w/cm	Minimum f_c', psi	Additional requirements	Limits on cementitious materials
			Air content	
W0	N/A	2500	None	
W1	N/A	2500	26.4.2.2(d)	
~~W1~~ W2	0.50	4000	~~None~~ 26.4.2.2(d)	

19.3 Concrete Durability Requirements: Exposure to Water

26.4.2.2(d) For concrete identified as being exposed to water in service, evidence shall be submitted that the concrete mixture complies with (1) and (2).

1) Aggregates are not alkali-silica reactive or measures to mitigate alkali-silica reactivity have been established.

2) Aggregates are not alkali-carbonate reactive.

19.3 Concrete Durability Requirements: Exposure to Sulfate

An Option 2 is added in the requirements for Exposure Class S3 in Table 19.3.2.1

- Maximum w/cm reduced to 0.40 from 0.45
- Minimum f_c' increased to 5000 psi from 4500 psi
- Allows use of Type V cements without pozzolans or slag cement
- Allows use of C595 HS and C1157 HS blended cements without additional pozzolans or slag cement

19.3 Concrete Durability Requirements: Provisions for Shotcrete

- Provisions for shotcrete are added throughout ACI 318-19 for the first time.
- Even though shotcrete has already been recognized by ACI 318, there were no provisions covering the material or process.
- New provisions are adapted from those first included in the 2000 IBC.

Chapter 20—Steel Reinforcement Properties, Durability, and Embedments

20.2.1.3 Exclusion of No. 20 Bars

20.2.1.3 Deformed bars shall conform to (a), (b), (c), (d), or (e), except bar sizes larger than No. 18 shall not be permitted

- ASTM A615-18ε^1 referenced in ACI 318-19 includes No. 20 bars
- There is a lack of information on the performance of these large bars including bar bending and development lengths

20.2.1.3 Additional Requirements for ASTM A615 and ASTM A706 bars

- Requirements additional to those included in the ASTM specifications are added for ASTM A615 (Gr. 40, 60, 80, 100) and ASTM A706 (Gr. 60, 80) bars
- The added requirements
  - Provide for harmonization of minimum tensile strength requirements between those two materials,
  - Add new ductility requirements to both materials,
  - Introduce Grade 100 reinforcement into ASTM A706.

20.2.1.3 Additional Requirements for ASTM A615 and ASTM A706 bars

Added Requirements for ASTM A615

(a) ASTM A615 – carbon steel, including requirements specified in Table 20.2.1.3(a)

Table 20.2.1.3(a)—Modified tensile strength and additional tensile property requirements for ASTM A615 reinforcement

	Grade 40	Grade 60	Grade 80	Grade 100
Tensile strength, minimum, psi	60,000	80,000	100,000	115,000
Ratio of actual tensile strength to actual yield strength, minimum	1.10	1.10	1.10	1.10

20.2.1.3 Additional Requirements for ASTM A615 and ASTM A706 bars

Added Requirements for ASTM A706

(b) ASTM A706 – low-alloy steel, including requirements specified in (i), (ii), and (iii):

(i) Tensile property requirements for ASTM A706 Grade 100 reinforcement shall be as specified in Table 20.2.1.3(b), and bend test requirements for ASTM A706 Grade 100 reinforcement shall be the same as the bend test requirements for ASTM A706 Grade 80 reinforcement.

20.2.1.3 Additional Requirements for ASTM A615 and ASTM A706 bars

Added Requirements for ASTM A706

Table 20.2.1.3(b)—Tensile property requirements for ASTM A706 Grade 100 reinforcement

	Grade 100
Tensile strength, minimum, psi	117,000
Ratio of actual tensile strength to actual yield strength, minimum	1.17
Yield strength, minimum, psi	100,000
Yield strength, maximum, psi	118,000
Fracture elongation in 8 in., minimum, %	10

20.2.1.3 Additional Requirements for ASTM A615 and ASTM A706 bars

Added Requirements for ASTM A706

(ii) Uniform elongation requirements for all grades of ASTM A706 reinforcement shall be as specified in Table 20.2.1.3(c), and uniform elongation shall be determined as the elongation at the maximum force sustained by the reinforcing bar test piece.

20.2.1.3 Additional Requirements for ASTM A615 and ASTM A706 bars

Added Requirements for ASTM A706

Table 20.2.1.3(c)—Uniform elongation requirements for ASTM A706 reinforcement

	Grade 60	Grade 80	Grade 100
Uniform elongation, minimum, percent			
Bar designation No.			
3, 4, 5, 6, 7, 8, 9, 10	9	7	6
11, 14, 18	6	6	6

20.2.2.4 Wider Acceptance of High-Strength Reinforcement

- Based on recent research demonstrating satisfactory performance, Grade 80 and 100 reinforcement are now permitted in more seismic and nonseismic applications.
- Table 20.2.2.4(a), *Nonprestressed deformed reinforcement*, is updated accordingly.

20.2.2.4 Wider Acceptance of High-Strength Reinforcement

Table 20.2.2.4(a) (Partial)

Usage	Application		Maximum value of f_y or f_{yt} permitted for design calculations, psi	Applicable ASTM specification for deformed bars
Flexure; axial force; and shrinkage and temperature	Special seismic system	Special moment frames	~~60,000~~ 80,000	A706[2]
		Special structural walls	~~60,000~~ 100,000	
	Other		~~80,000~~ 100,000	A615, A706, A955, A996, A1035

[2]ASTM A615 Grade 60 shall be permitted if requirements of 20.2.2.5(b) are satisfied.

20.2.2.4 Wider Acceptance of High-Strength Reinforcement

Table 20.2.2.4(a) (Partial)

Usage	Application		Maximum value of f_y or f_{yt} permitted for design calculations, psi	Applicable ASTM specification for deformed bars
Shear	Special seismic system	Special moment frames	~~60,000~~ 80,000	A615, A706, A955, A996
		Special structural walls	~~60,000~~ 100,000	

20.2.2.4 Wider Acceptance of High-Strength Reinforcement

Usage	Application	Maximum value of f_y or f_{yt} permitted for design calculations, psi	Applicable ASTM specification for deformed bars
Anchor reinforcement	Special seismic systems	80,000	A706[2]
	Other	80,000	A615, A706, A955, A996
Regions designed using strut-and-tie method	Longitudinal ties	80,000	A615, A706, A955, A996
	Other	60,000	

[2]ASTM A615 Grade 60 shall be permitted if requirements of 20.2.2.5(b) are satisfied.

20.2.2.5 Reinforcement Properties for Seismic Applications

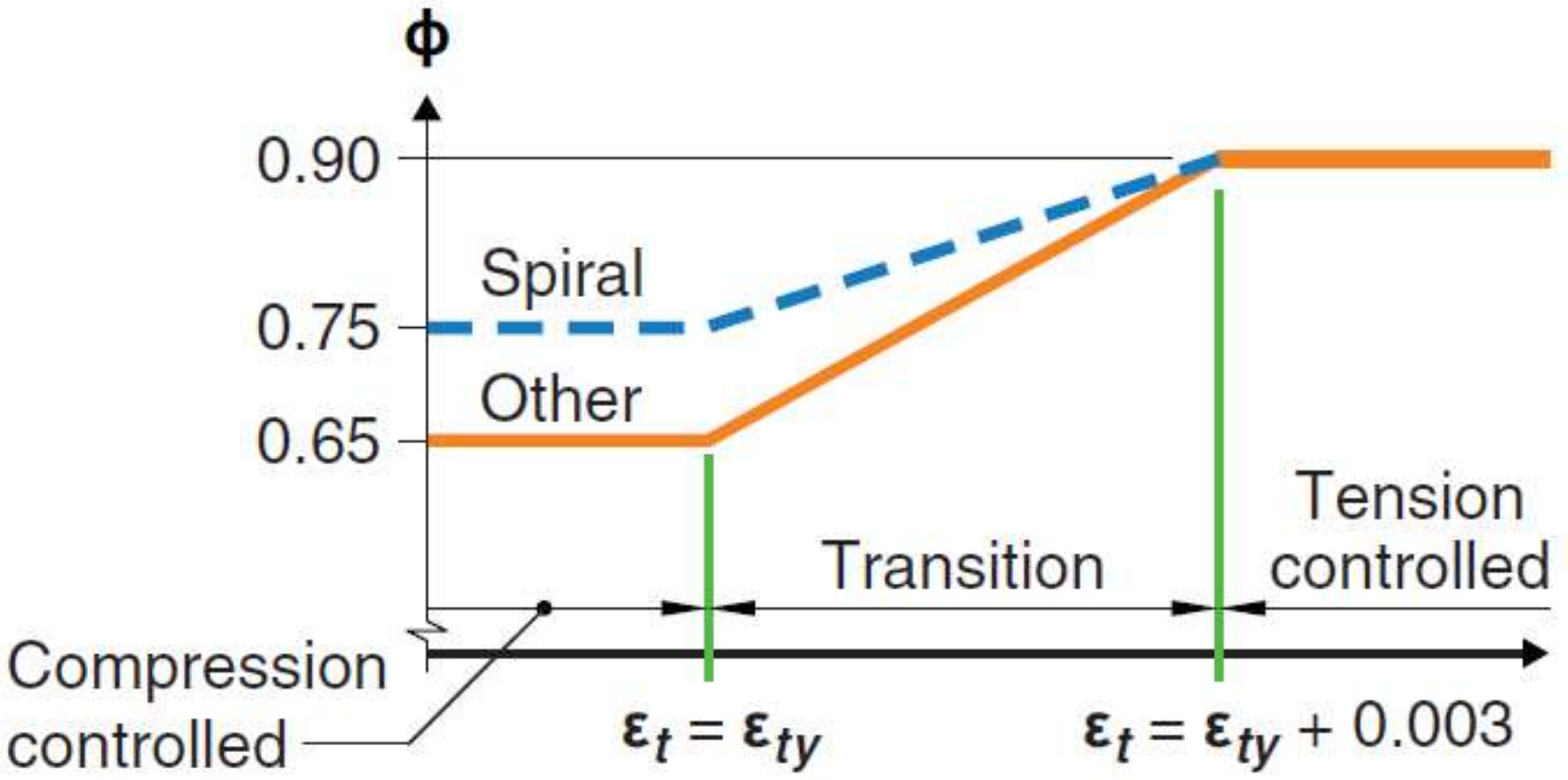
- Minimum elongation requirements revised for ASTM A615 Gr. 60 bars to be used as longitudinal reinforcement in high seismic applications
- Revisions make the elongation requirements the same as the revised requirements for ASTM A706 Gr. 60 bars.
- ASTM A615 Gr. 80 and 100 bars are still not permitted in high seismic applications.

20.5.1.3.4 Reinforcement Cover for Deep Foundation Members

- Cover requirement for deep foundation members are added in new Table 20.5.1.3.4
- Adopted from 2018 IBC Table 1808.8.2 and ACI 543R-12 Table 4.5.3.6
- This should allow IBC to omit the cover requirements in future editions

Chapter 21—Strength Reduction Factors

21.2.2 ϕ for Flexure, Axial Force, or Combination



21.2.4.3 ϕ for Shear for Foundation Elements

21.2.4.3 For foundation elements supporting the primary seismic force-resisting system, ϕ for shear shall not exceed the least value of ϕ for shear used for the vertical components of the primary seismic force-resisting system.

R21.2.4.3 This provision is intended to provide consistent reliability for shear in foundation elements that support shear-controlled walls designed with a strength reduction factor of 0.6.

Chapter 22—Sectional Strength

ACI 318-19

- One-way shear equations changed for nonprestressed members with the primary objectives of including size effect and longitudinal reinforcement ratio on shear strength.

Updated Calculation of V_c

Accounting for Size Effect

V_c does not change in direct proportion to member depth as suggested by conventional expressions such as:

$$V_c = 2\lambda\sqrt{f'_c}b_w d$$

Doubling the member depth does not lead to twice the concrete contribution toward resisting shear.

Size Effect – Experimental Evidence

Fig. 8: Construction and loading of the large, wide beam, AT-1 under testing machine at the University of Toronto

Lubell, A., Sherwood, T., Bentz, E., Collins, M. P. (2004). Safe Shear Design of Large, Wide Beams. Concrete International. 26. 66-78.

Size Effect – Experimental Evidence

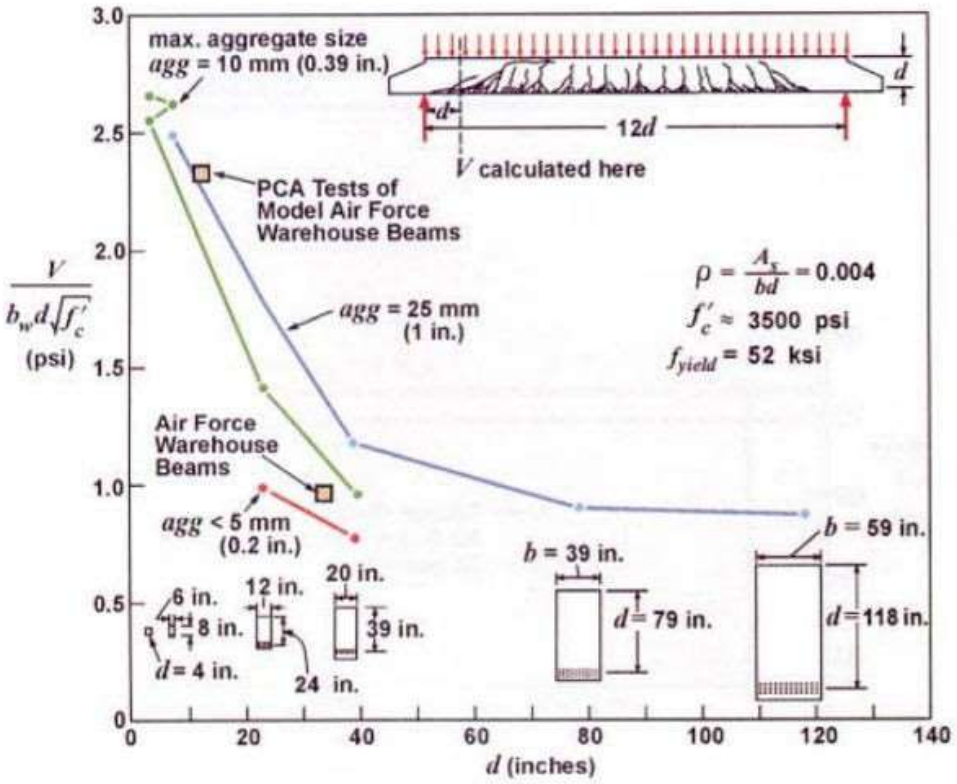


Fig. 5: Influence of member depth and maximum aggregate size on shear stress at failure (tests by Shioya et al.[9] and Shioya[10]) (1 in. = 25.4 mm; 1 ksi = 6.89 MPa; 1 psi = 6.89 kPa)

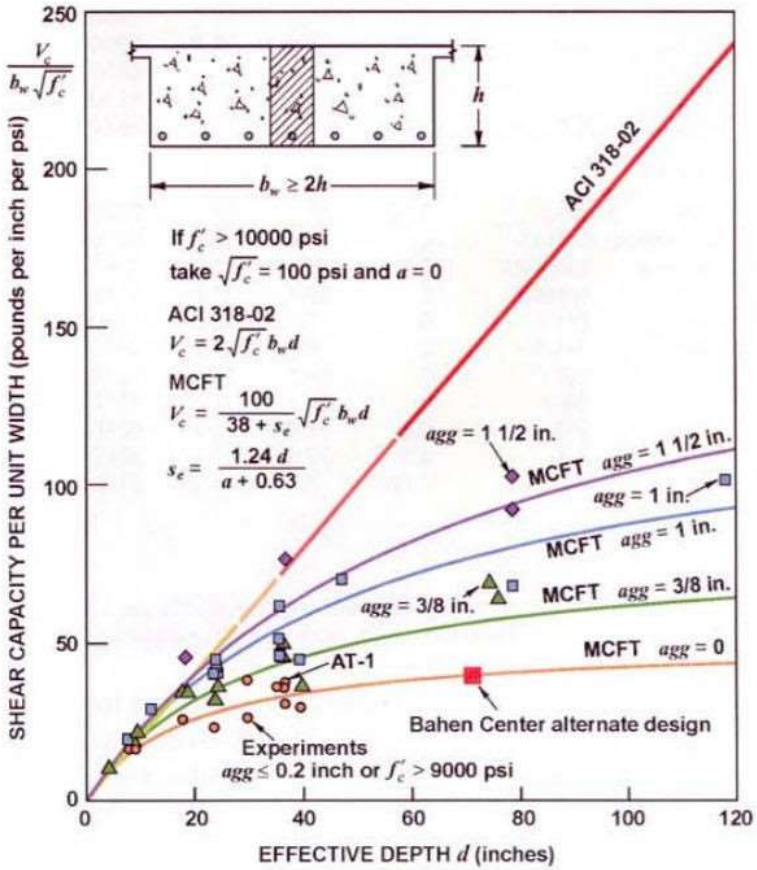


Fig. 13: Safety of ACI shear design procedure for large, wide beams (1 in. = 25.4 mm; 1 lb/in./psi = 0.025 kN/m/kPa; and 1 psi = 6.89 kPa)

Lubell, A., Sherwood, T., Bentz, E., Collins, M. P. (2004). Safe Shear Design of Large, Wide Beams. Concrete International. 26. 66-78.

Updated Calculation of V_c

Accounting for Size Effect

New size effect modification factor, λ_s, has been introduced to modify the expressions to calculate V_c for

- beams without shear reinforcement
- two-way slabs with or without shear reinforcement

$$\lambda_s = \sqrt{\frac{2}{1+\frac{d}{10}}} \le 1 \qquad (22.5.5.1.3)$$

Updated Calculation of V_c

Simplification in Calculation of V_c for beams

- 8 expressions in ACI 318-14 reduced to 3
- New expressions work well for varying amounts of shear reinforcement provided (A_v)
- New expressions work well with varying axial compressive stresses applied.
- Accounts for longitudinal reinforcement ratios in members without shear reinforcement

Updated Calculation of V_c

Simplification in Calculation of V_c for beams

ACI 318-19 expressions for V_c for nonprestressed members

Table 22.5.5.1—V_c for nonprestressed members

Criteria	V_c		
$A_v \geq A_{v,min}$	Either of:	$\left[2\lambda\sqrt{f_c'} + \frac{N_u}{6A_g}\right] b_w d$	(a)
		$\left[8\lambda(\rho_w)^{1/3}\sqrt{f_c'} + \frac{N_u}{6A_g}\right] b_w d$	(b)
$A_v < A_{v,min}$	$\left[8\lambda_s\lambda(\rho_w)^{1/3}\sqrt{f_c'} + \frac{N_u}{6A_g}\right] b_w d$		(c)

Size Effect Factor

Notes:

1. Axial load, N_u, is positive for compression and negative for tension.
2. V_c shall not be taken less than zero.

Updated Calculation of V_c

Simplification in Calculation of V_c for beams

ACI 318-19 expressions for V_c for nonprestressed members

22.5.5.1.1 V_c shall not be taken greater than $5\lambda\sqrt{f_c'}\,b_w d$.

22.5.5.1.2 In Table 22.5.5.1, the value of $N_u/6A_g$ shall not be taken greater than $0.05f_c'$.

Updated Calculation of V_c

Simplification in Calculation of V_c for beams

- New expressions still unconservative for concrete with strength higher then 10,000 psi.
  - ACI 318-19 Section 22.5.3.1 still limits concrete strength at 10,000 psi for the purpose of calculating concrete shear strength unless enhanced minimum transverse reinforcement is provided

Updated Calculation of V_c:Two-Way Slabs without Shear Reinforcement

Table 22.6.5.2—v_c for two-way members without shear reinforcement

v_c		
Least of (a), (b), and (c):	$4\lambda_s\lambda\sqrt{f'_c}$	(a)
	$\left(2+\frac{4}{\beta}\right)\lambda_s\lambda\sqrt{f'_c}$	(b)
	$\left(2+\frac{\alpha_s d}{b_o}\right)\lambda_s\lambda\sqrt{f'_c}$	(c)

Updated Calculation of V_c:Two-Way Slabs without Shear Reinforcement

Table 22.6.6.1—v_c for two-way members with shear reinforcement

Type of shear reinforcement	Critical sections	v_c		
Stirrups	All	$2\lambda_s\lambda\sqrt{f'_c}$		(a)
Headed shear stud reinforcement	According to 22.6.4.1	Least of (b), (c), and (d):	$3\lambda_s\lambda\sqrt{f'_c}$	(b)
			$\left(2+\frac{4}{\beta}\right)\lambda_s\lambda\sqrt{f'_c}$	(c)
			$\left(2+\frac{\alpha_s d}{b_o}\right)\lambda_s\lambda\sqrt{f'_c}$	(d)
	According to 22.6.4.2		$2\lambda_s\lambda\sqrt{f'_c}$	(e)

22.6.4.2 – Critical section beyond where punching shear reinforce-ment ends

Other Changes
Correction: Torsional Strength T_n

22.7.6.1 For nonprestressed and prestressed member, T_n shall be the lesser of (a) and (b):

(a) ……

(b) $$T_n = \frac{2A_oA_\ell f_y}{p_h} \cot\theta \quad \underline{\tan\theta}$$

Chapter 23—Strut and Tie Models

Major Changes

- Revisions in how to incorporate prestressing forces
- New factor β_c for struts and nodal zones to account for concrete confinement
- Revisions in strut coefficient β_s
- Revised provisions for controlling diagonal cracking in struts
- New provisions for curved-bar nodes
- New provisions for seismic design

Chapter 24—Serviceability Requirements

R24.1—Scope

R24.1 … This chapter has no specific requirements for vibrations.

Cast-in-place floor systems designed in accordance with the minimum thickness and deflection requirements of 7.3, 8.3, 9.3, and 24.2 have generally been found, through experience, to provide vibration performance suitable for human comfort under typical service conditions. However, there may be situations where serviceability conditions are not satisfied, for example:

R24.1—Scope

R24.1(Contd.)

- Long spans and open floor plans,
- Floors with strict vibration performance requirements such as precision manufacturing and laboratory spaces,
- Facilities subject to rhythmic loadings or vibrating mechanical equipment.

Chapter 25—Reinforcement Details

ACI 318-19

- Straight bar development length unchanged, except for introduction of reinforcement grade factor
- Hooked bar development length changed: diameter to the power 1.5, correction factor for f_c' below 6000 psi, limit of 100 psi on square root of f_c' retained

25.4.2 – Development of Deformed Bars and Deformed Wires in Tension

Table 25.4.2.3 – Development length for deformed bars and deformed wires in tension

Spacing and cover	No. 6 and smaller bars and deformed wires	No. 7 and larger bars
Clear spacing of bars or wires being developed or lap spliced not less than d_b, clear cover at least d_b, and stirrups or ties throughout ℓ_d not less than the Code minimum or Clear spacing of bars or wires being developed or lap spliced at least 2db and clear cover at least d_b	$\left(\frac{f_y \psi_t \psi_e \psi_g}{25\lambda\sqrt{f_c'}}\right) d_b$	$\left(\frac{f_y \psi_t \psi_e \psi_g}{20\lambda\sqrt{f_c'}}\right) d_b$
Other Cases	$\left(\frac{3f_y \psi_t \psi_e \psi_g}{50\lambda\sqrt{f_c'}}\right) d_b$	$\left(\frac{3f_y \psi_t \psi_e \psi_g}{40\lambda\sqrt{f_c'}}\right) d_b$

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25.4.2 – Development of Deformed Bars and Deformed Wires in Tension

- Equation 25.4.2.3a has been modified

$$l_d = \left(\frac{3}{40} \frac{f_y}{\lambda \sqrt{f_c'}} \frac{\psi_t \psi_e \psi_s \underline{\psi_g}}{\left(\frac{c_b + K_{tr}}{d_b} \right)} \right) d_b$$

- The values of Ψ_g are included in Table 25.4.2.5.

Reinforcement grade ψ_g	Grade 40 or Grade 60	1.0
	Grade 80	1.15
	Grade 100	1.3

ACI 318-14 Section 25.4.3.1

25.4.3.1 Development length l_{dh} for deformed bars in tension terminating in a standard hook shall be the greater of (a) through (c):

(a) $\left(\dfrac{f_y \psi_e \psi_c \psi_r}{50\lambda\sqrt{f'_c}}\right) d_b$ with ψ_e, ψ_c, ψ_r, and λ given in 25.4.3.

(b) $8d_b$

(c) 6 in.

e for epoxy-coating, c for cover, r for confining reinf.

25.4.3 – Development of Standard Hooks in Tension

Equation provided in Section 25.4.3.1 (a) modified to include Ψ_o, the location factor.

$$\left(\frac{f_y \Psi_e \Psi_r \Psi_o \Psi_c}{55\lambda\sqrt{f_c'}} \right) d_b^{1.5}$$

Ψ_o is the factor used to modify development length based on bar placement within member (controlled by side cover and location inside or outside a confined column core

Ψ_r, still confining reinf. factor, is modified; Ψ_c is now concrete strength factor

25.4.4 – Development of Headed Deformed Bars in Tension

25.4.4.1 Use of a head~~s~~ to develop a deformed bar~~s~~ in tension shall be permitted if conditions (a) through (~~g~~f) are satisfied:

~~(b) Bar f_y shall not exceed 60,000 psi~~

(~~g~~f) Center-to-center ~~Clear~~ spacing between bars shall be at least ~~4~~3d_b

25.4.4 – Development of Headed Deformed Bars in Tension

- Equation for ℓ_{dt} in 25.4.4.2 (a) is modified as shown below:

$$\cancel{\left(\frac{0.016 f_y \Psi_e}{\sqrt{f_c'}}\right) d_b} \left(\frac{f_y \Psi_e \Psi_p \Psi_o \Psi_c}{75\sqrt{f_c'}}\right) d_b^{1.5}$$

- Table 25.4.4.3 provides the values for Ψ_e, Ψ_p, Ψ_o, and Ψ_c

25.4.10 – Reduction of Development Length for Excess Reinforcement

25.4.10.1, 25.4.10.2 no longer permit the use of the $(A_{s,required})/(A_{s,provided})$ term to reduce the development length of hooked, headed, and mechanically anchored deformed reinforcement.

R25.4.10.2 – Reduction of Development Length for Excess Reinforcement

R25.4.10.2 The excess reinforcement factor ($A_{s,required}/A_{s,provided}$), applicable to straight reinforcement is not applicable for hooked or headed bars where force is transferred through a combination of bearing at the hook or head and bond along the bar. Concrete breakout due to bearing at a hook or head was considered in developing the provisions of 25.4.3 and 25.4.4. Because the anchorage strength, and in particular the concrete breakout strength of a hooked or headed bar is a function of the embedment depth to a power slightly more than 1.0, a reduction in development length with the application of the excess reinforcement factor could result in a potential concrete breakout failure.

25.4.10 – Reduction of Development Length for Excess Reinforcement

25.4.10.2 presents cases where reduction of development length is not permitted.

(d) For hooked, headed, and mechanically anchored deformed reinforcement

(e) In seismic force-resisting systems in structures assigned to Seismic Design Categories C, D, E, or F.

(f) Anchorage of concrete piles to pile caps in structures assigned to Seismic Design Categories C, D, E, or F.

25.5 – Splices

- Requirements for transverse reinforcement for bars with $f_y \geq 80{,}000$ psi (Grade 100 reinforcement) are provided in 25.5.1.5.
- Lap splice length of deformed bars in compression is adjusted for Gr. 80 and Gr. 100 reinforcement.

Chapter 26—Construction Documents and Inspection

26.2 – Design Criteria

26.2.2 Compliance Requirements [New]

(a) Design work delegated to the contractor shall be performed by a specialty engineer.

(b) The contractor's specialty engineer, relying on the documents identifying the portion of design work assigned, shall produce design work that is compatible with the construction documents and the design criteria provided by the licensed design professional in charge of the design work.

26.2 – Design Criteria

26.2.2 (Contd.)

(c) The contractor shall submit necessary information to the licensed design professional to confirm that the specialty engineer complied with the documents identifying the portion of the design work assigned.

Changes Due to Addition of Shotcrete to ACI 318-19

26.12—Evaluation and Acceptance of Hardened Concrete

Added shotcrete evaluation and acceptance criteria. Acceptance criteria are in a new Section 26.12.4.

26.4 Concrete Materials and Mixture

26.4.1 *Concrete materials*

26.4.1.1 *Cementitious materials*

26.4.1.1.1 Compliance Requirements

(b) Alternative cements shall be permitted if approved by the licensed design professional and the building official. Approval shall be based upon test data documenting that the proposed concrete mixture made with the alternative cement meets the performance requirements for the application including structural, fire, and durability.

26.4 Concrete Materials and Mixture

26.4.1.2 *Aggregates*

26.4.1.2.1 Compliance Requirements

(a) Aggregates shall conform to (1), ~~or~~ (2), or (3):

(3) Mineral fillers: ASTM C1797.

(c) Crushed hydraulic-cement concrete or recycled aggregate shall be permitted if approved by the licensed design professional and the building official based on documentation that demonstrates compliance with (1) and (2).

26.4 Concrete Materials and Mixture

26.4.1.2.1 Compliance Requirements

(c) (Contd.)

(1) Concrete incorporating the specific aggregate proposed for the Work has been demonstrated to provide the mechanical properties and durability required in structural design.

(2) A testing program to verify aggregate consistency and a quality control program to achieve consistency of properties of the concrete are conducted throughout the duration of the project.

26.13.1 – Inspection, General

A number of subsections have been modified.

26.13.1.1 Concrete construction shall be inspected as required by the general building code, and as a minimum, the inspection shall comply with the requirements provided in 26.13. In the absence of a general building code, concrete construction shall be inspected in accordance with the provisions of this Code.

Chapter 27—Strength Evaluation of Existing Structures

Reorganization

- Section 27.5 modified and New Section 27.6 added.
  - 27.5–Monotonic load test procedure
  - 27.6–Cyclic load test procedure

27.2 General

3118-14 27.5.1 is now 27.2.5

27.2.5 If the structure under investigation does not satisfy conditions or criteria of 27.3 [Analytical Strength Evaluation] ~~or 27.4.5~~, 27.5, or 27.6, the structure shall be permitted for use at a lower load rating, based on the results of the load test or analysis, and if approved by the building official.

27.3 Analytical Strength Evaluation

27.3.1.1 As-built d~~D~~imensions of members shall be ~~established~~ field-verified at critical sections.

27.3.1.3 If required, an estimated equivalent f_c' shall be based on analysis of results of cylinder tests from the original construction~~s~~ ~~or~~, tests of cores removed from ~~the part of~~ the structure, ~~where strength is in question~~ or both sets of data. Original cylinder data and core test data shall be representative of the area of concern.

27.4.6 – Test Load Arrangement and Load Factors

(a) $T_t = 1.0D_w + 1.1D_s + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$

(b) $T_t = 1.0D_w + 1.1D_s + 1.0^*L + 1.6(L_r \text{ or } S \text{ or } R)$

(c) $T_t = 1.3(D_w + D_s)$

*Permitted to be reduced to 0.5

Reason: To be consistent with the requirements of ACI 437.2

27.5 – Monotonic Load Test Procedure

~~27.4.5.5~~ **27.5.3.5** Measured deflections shall satisfy ~~(a) or (b)~~:

~~(a)~~ $$\Delta_1 \le \frac{l_t^2}{20{,}000h}$$ ~~(27.4.5.5a)~~

~~(b)~~ $$\Delta_r \le \frac{\Delta_1}{4}$$ (~~27.4.5.5b~~27.5.3.5)

27.5.3.6 If the maximum deflection measured during the test, Δ_1, does not exceed the larger of 0.05 in. or $\ell_t/2000$, the residual deflection requirements in 27.5.3.5 shall be permitted to be waived.

27.6 – Cyclic Load Test Procedure [New]

27.6.1 A cyclic load test in accordance with ACI 437.2 shall be permitted to be used to evaluate the strength of an existing structure.

27.6.2 Acceptance criteria for cyclic load test results shall be in accordance with ACI 437.2.

Appendix A—Design Verification Using Nonlinear Response History Analysis

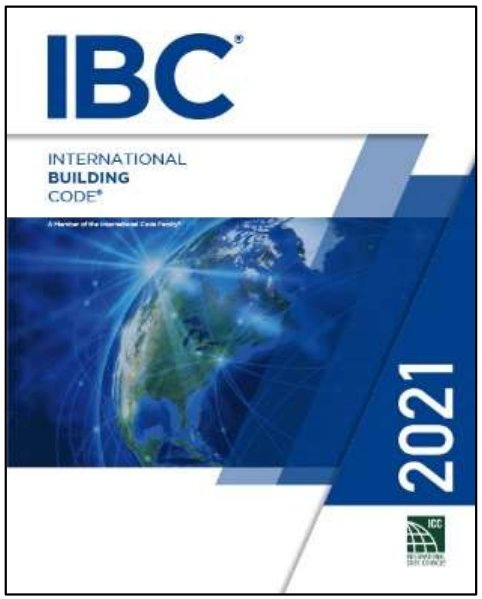
New! Appendix A

- Provides a set of requirements for nonlinear response history analysis
- Supplemental to those in ASCE 7 Chapter 16
- The provisions of Appendix A are in addition those of Chapters 1 through 26
- Requires a licensed design professional to implement this appendix
- Requires an independent design review

ACI 318-19

ACI 318-19 is or will be the referenced standard for concrete design and construction in

- The 2021 IBC
- ASCE 7-22



The 2021 IBC will be adopted by the State of California on January 1, 2023.

Thank You!!

For more information…

www.skghoshassociates.com

Phone: (847) 991-2700

Email: kbhaumik@skghoshassociates.com

Follow us on:

File Attachments for Item:

EC-9 Electric Vehicle Power Transfer Systems and the 2020 NEC Part 2 (Matthews Electrical Services)

All certifications (4 hours)

BIOGRAPHY
Henry P. Matthews PE, CPE, CESCP, PVA

Henry has over 31 years of experience in the electrical design, construction, engineering and safety fields. He has a passion for teaching and mentoring.

Henry obtained his Bachelor of Science degree in Electrical Engineering from Penn State University in 1989.

He also earned a Master of Business Administration from Bowling Green State University in 2003.

In addition, Henry earned several certificates including:

- Plumbing and Electrician from Penn Foster Career School
- Welding from Owens Community College in Findlay, Ohio
- Residential Solar PV Systems from Solar Engineering International

Henry currently holds the following licenses, and memberships:

- Licensed Electrical Contractor in Ohio
- Licensed Training Agency in Ohio
- Licensed Professional Engineer in Ohio, Michigan, Kentucky, Indiana, Illinois, Wisconsin
- Certified Plant Engineer (CPE)
- Certified Building Operator (CBO)
- Certified Electrical Compliance Safety Professional (CESCP) by NFPA
- Solar PV Associate by the North American Board of Certified Energy Practitioners
- Electric Vehicle Infrastructure Training Program (EVITP) certification
- Senior Member of the Institute of Electrical and Electronic Engineers (IEEE)
- Member of the International Association of Electrical Inspectors (IAEI)
- Member of the National Fire Protection Association (NFPA)

Henry is currently employed as an Advanced Senior Engineer for Marathon Petroleum Company in Findlay, Ohio. During his 16 years at Marathon, Henry has worked as an Electrical Design Engineer, Project Engineer, Engineering Supervisor and currently as a Reliability Engineer.

Henry is also the owner of Matthews Electrical Services, a small, but full-service electrical contractor company.

Prior to this, he worked 13 years as an Electrical Engineer and a Plant Engineering Manager in at Cooper Standard Automotive, a major automotive parts supplier in Bowling Green, Ohio

Henry is the past co-chair of American Petroleum Institute Recommended Practice 545 Lightning Protection for Above Ground Storage Tanks.

He was also past president of the Fostoria Toastmaster club.

Electrical Vehicle Power Transfer Equipment and the NEC Part 2

Outline

Relevant NEC Chapters and Articles (Based on the 2020 NEC)

- Article 625 Electric Vehicle Power Transfer Systems
- Article 100 Key Definitions
- Article 250 Grounding and Bonding
- Chapter 3 Wiring Methods and Materials
- Chapter 9 Tables

Other Resources:

- NFPA 70E (2021) Electrical Safety in the Workplace
- NECA 413 Standard for Installing and Maintaining Electrical Vehicle Supply Equipment (EVSE)
- OSHA 1910 Subpart S Electrical Safety

Referenced Websites:

- www.NFPA.org
- NREL – National Renewable Energy Laboratories
- www.IAEI.org (International Association of Electrical Inspectors)
- www.mikeholt.com
- www.esfi.org Electrical Safety Foundation International)
- Multiple automobile and Class 2/DC Fast charger manufacturer websites

Course Content:

- Electrical Safety review with emphasis on DC systems
- NEC definitions
- Electric Vehicle Infrastructure
    - Non-residential installations
    - Fleet considerations
- ADA Considerations
- Installation requirements
- Example Installations

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Henry P. Matthews

Organization: Matthews Electrical Services

Address: 1203 McKinley Place; Fostoria, Ohio 4830

E-mail: hpmatthews@matthewselectrical.net Telephone: 419-575-3488

Website: www.matthewselectrical.net

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Electric Vehicle Power Transfer Systems and the NEC Part 2

Course instructor: Henry P. Matthews

Course description: This course will cover article 625 in the NEC for electric vehicle power transfer systems. This course will follow up on Electric Vehicle Power Transfer Systems and the NEC Part 1 and will focus on code-compliant installations. Examples of a single phase Level 2 charger installation and a three-phase level 2 charger will be presented and explained.

Instructional hours per session: 4 Number of Sessions: at least one per quarter

Course Date(s) and Location: , 5-27-2023 via Zoom. Registration at www.matthewselectrical.net

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online?__✓___ **On Demand**_____ **Webinar**__✓___

Course Website: www.matthewselectrical.net

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Surveys, polls, and roll call after each break will be conducted.

Course applicable for the following certifications

Residential Certifications Only: __✓___ Commercial Certifications: __✓___

Administrative Course, All Certifications: _____

Application materials included:

__✓___ Course Outline or Course Learning Objectives

__✓___ Presentation Materials/Slides (not required for roundtable courses)

__✓___ Assessment Materials (for online courses)

__✓___ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

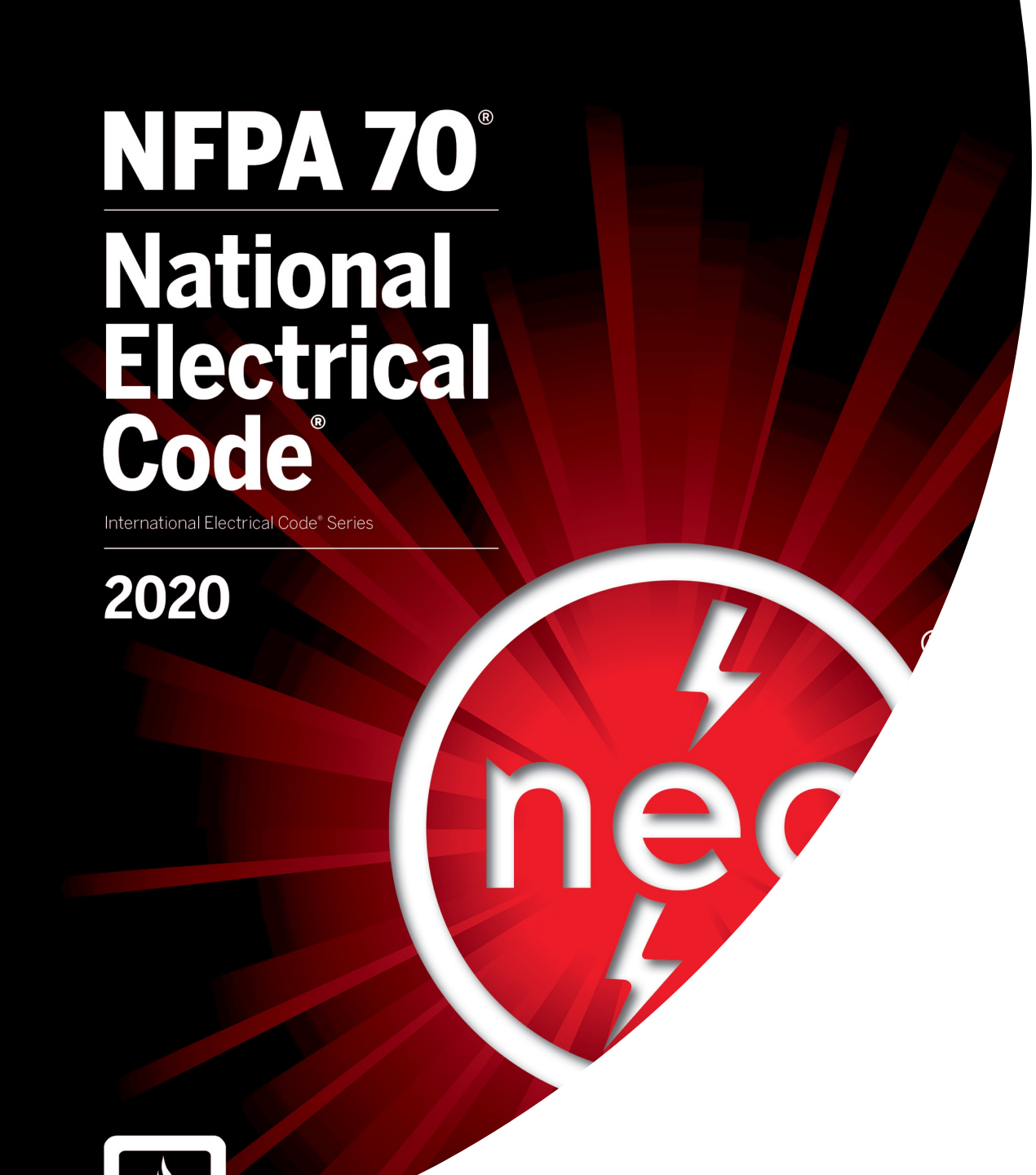
Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov



Electric Vehicle Power Transfer Systems and the NEC Part 2

OCILB Course # 4871435

The 2020 NEC has not been adopted in Ohio. PRESENTED FOR INFORMATIONAL PURPOSES ONLY

Notice!

This course is based on the 2020 NEC.

The 2020 NEC has not been adopted in Ohio

Presented for INFORMATIONAL PURPOSES ONLY.

Webinar Rules

- Attendee must be present the entire time (except breaks)
- Mute microphone at all times
  - Prevents distraction during webinar
  - Instructor may activate participant microphone if verbal response is needed

Webinar Rules (Continued)

- 5 minute breaks every hour
  - Return promptly after breaks
  - The instructor will check attendance after each break
- Emergencies
- Contingency Plans: Ohio Weather
- Unexpected interruption
  - Re-joining webinar
  - Problems:
    - send me a text message: 419-575-3488
    - Or email: hpmatthews66@att.net

Webinar Completion

- Certificate of completion will be sent via email to all attendees
- 4 hours of Code credits will be submitted to the OCILB and OBBS state boards within 48 hours of class
- Feedback is encouraged to improve future webinars!
- Send other inquires, feedback and questions to: hpmatthews@matthewselectrical.net
- 419-575-3488 (cell)

WELCOME!

- Goals
  - Promote learning
  - Make session engaging
    - Discussion
    - Videos
    - Case Studies
    - Polls
  - Make 4 hours as productive as possible!

eLicense CENTER Ohio Department of Commerce
OCILB eLicense Center

HOME MY ACCOUNT ONLINE SERVICES

Continuing Education Class Search

Note: Click on the provider name to show any available details.

Course Number	Course Name	Subject	Hours	Provider	Location	Date	Time	Phone	Address
4871435	ELECTRIC VEHICLE POWER TRANSFER SYSTEMS AND THE NEC PART 2	CODE	4.00	MATTHEWS ELECTRICAL SERVICES	www.matthewselectrical.net www.zoom.com 1203 McKinley Place Fostoria, OH 44830	01/14/2023	07:00	419-575-3488	1203 McKinley Pl Fostoria, OH 44830-4714
4871424	SOLAR PHOTOVOLTAICS AND THE NEC PART 1	CODE	4.00	MATTHEWS ELECTRICAL SERVICES	www.matthewselectrical.net www.zoom.com 1203 McKinley Place Fostoria, OH 44830	01/21/2023	07:00	419-575-3488	1203 McKinley Pl Fostoria, OH 44830-4714
4871429	SOLAR PHOTOVOLTAICS AND THE NEC PART 2 WEBINAR	CODE	4.00	MATTHEWS ELECTRICAL SERVICES	www.matthewselectrical.net www.zoom.com 1203 McKinley Place Fostoria, OH 44830	01/28/2023	07:00	419-575-3488	1203 McKinley Pl Fostoria, OH 44830-4714

CERTIFICATE OF COMPLETION

THIS CERTIFIES THAT

JOE STUDENT

OCILB License no: 12345 (Electrical, Plumbing)

HAS SUCCESSFULLY COMPLETED THE TRAINING REQUIREMENTS FOR

Electrical Vehicle Power Transfer Systems Part 2

OCILB COURSE NO: 4871435

4 CODE CREDIT HOURS

January 14, 2023	MATTHEWS ELECTRICAL SERVICES Agency #48714	HENRY P. MATTHEWS PE, CESCP
DATE		INSTRUCTOR

Electric Vehicle EVITP™ Infrastructure Training Program

The Electric Vehicle Infrastructure Training Program

Presents this

Certificate of Completion

#4034465

of the 20 hour EVITP Installer Training Course

to

Henry Matthews

Date of Certification, September 21, 2022
Valid Through, September, 2025

Jennifer Mefford, EVITP Chair

Bernie Kotlier, EVITP Chair

Your Instructor: Henry Matthews

- Advanced Senior Engineer (Current): (16 yrs)
- Plant Engineering Manager: Cooper Standard Automotive (13 yrs)
- Electrical Designer: Toledo Engineering Company (4 yrs)
- BS Electrical Engineering – Penn State University
- MBA – Bowling Green State University
- Registered Professional Engineer – OH, IN, KY, WI, MI, IL,WV
- Certified Professional Engineer – CPE
- Certified Electrical Safety Compliance Professional (CESCP) by NFPA
- Licensed Electrical Contractor – OH
- Registered Training Agency – OCILB OH #48714
- Registered Training Agency – Ohio Board of Building Standards (BBS)
- Senior Member of IEEE
- Member of NFPA – Builders and Architects division
- Member of International Association of Electrical Inspectors (IAEI)
- Member of Association of Facility Engineers (AFE)
- Co-chair API RP 545 – Lightning Protection for Above Ground Storage Tanks
- Over 29 years in the electrical design, construction and standards industry

Mike DeWine
Governor

Sheryl Maxfield
Director

Ohio Construction Industry Licensing Board
Approved Training Agency

MATTHEWS ELECTRICAL SERVICES

Training Agency License: **48714**

Expiration Date: **10/17/2023**

Carol Ross

Carol A. Ross
Board Secretary

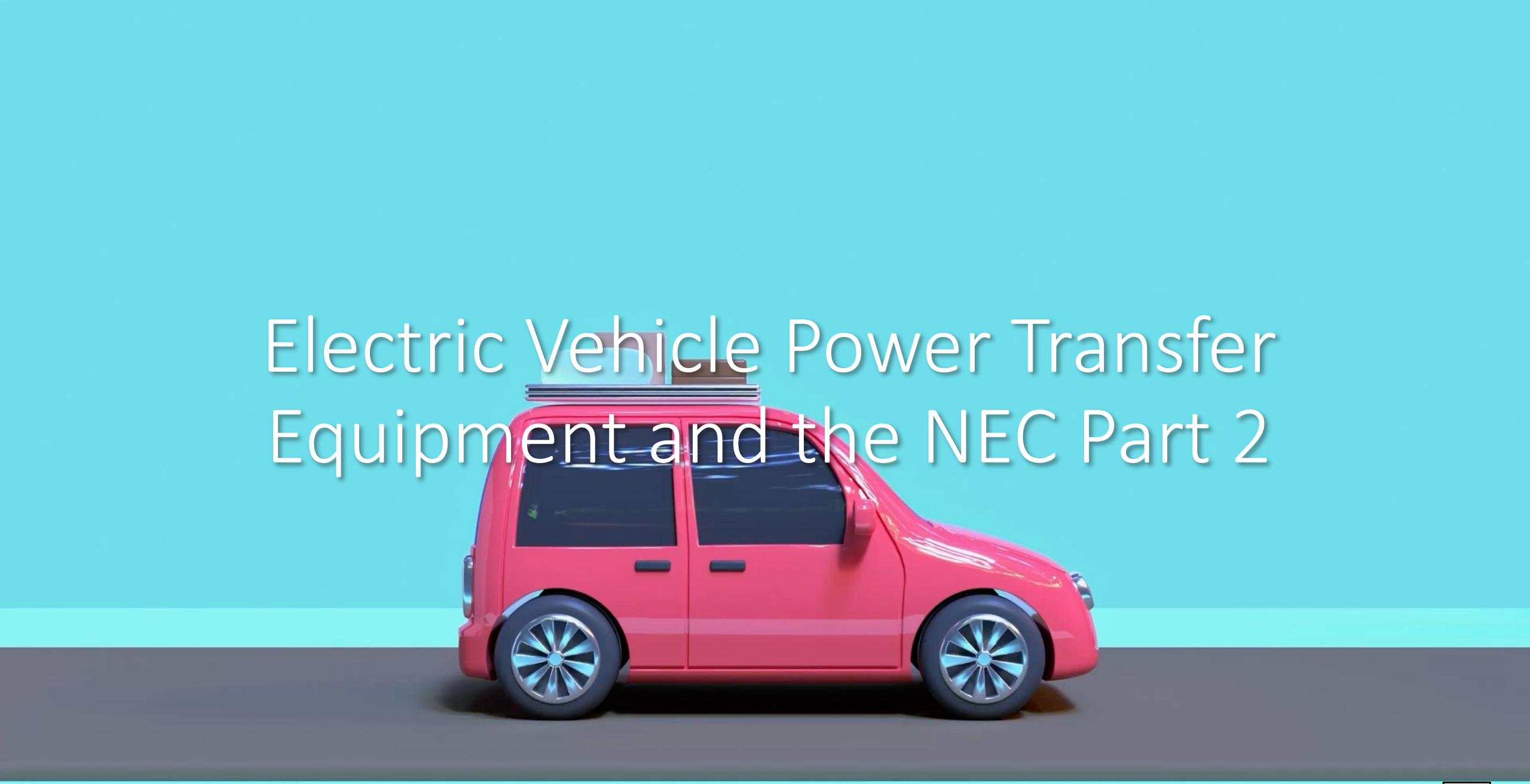
William Koester

William Koester
Administrative Chairman


Mike DeWine
Governor
Sheryl Maxfield
Director
LICENSE MUST BE POSTED ON JOB SITE
Electrical
CONTRACTOR'S LICENSE
HENRY P MATTHEWS
MATTHEWS ELECTRIC SERVICES
OWNER
Ohio License# 46972
Expiration Date: December 17, 2023
OHIO CONSTRUCTION INDUSTRY LICENSING BOARD
STATE OF OHIO
LICENSE MUST BE POSTED ON JOB SITE
Carol A. Ross
Board Secretary
William Koester
Administrative Chairperson

650

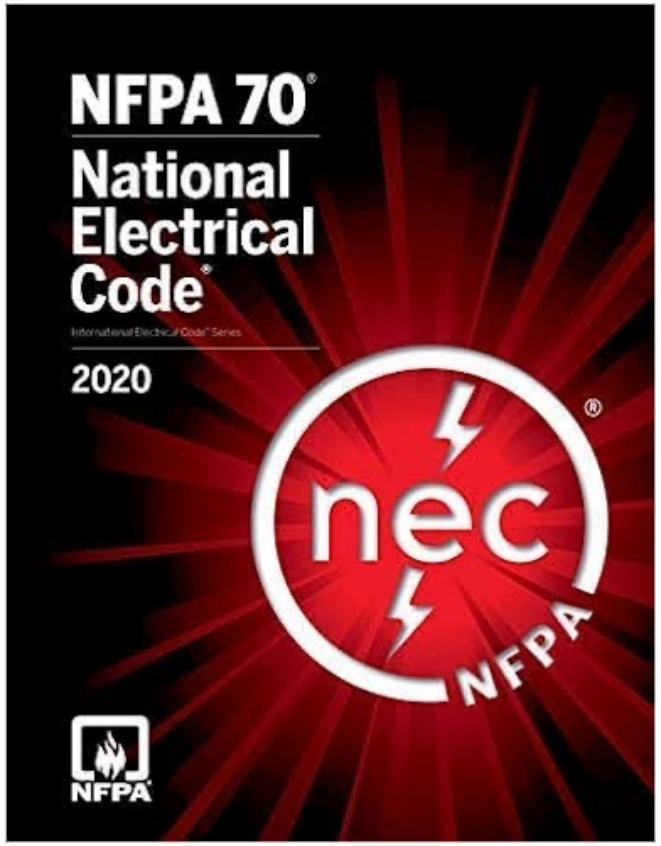
Electric Vehicle Power Transfer Equipment and the NEC Part 2

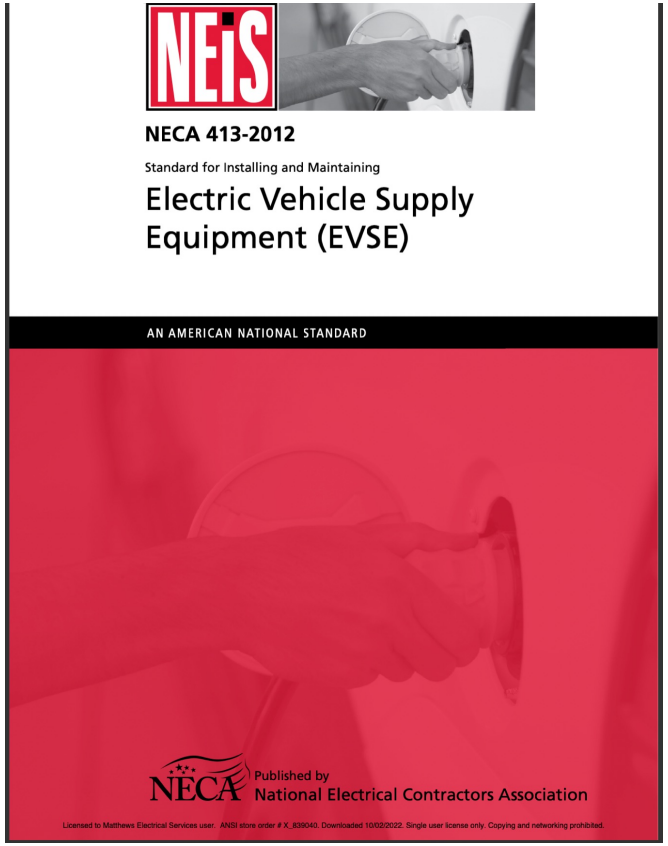


Agenda

- Part 1 review
- EV Current State
- Article 705: Interconnected Electrical Power Sources
- Residential Installation Example
- Commercial Examples:
  - Three-phase system power, single phase charger application
  - Three-phase system power, three phase charger app

Resources


NFPA 70®
National Electrical Code®
2020
nec
NFPA
NFPA


NEIS
NECA 413-2012
Standard for Installing and Maintaining
Electric Vehicle Supply Equipment (EVSE)
AN AMERICAN NATIONAL STANDARD
NECA
Published by
National Electrical Contractors Association

Websites

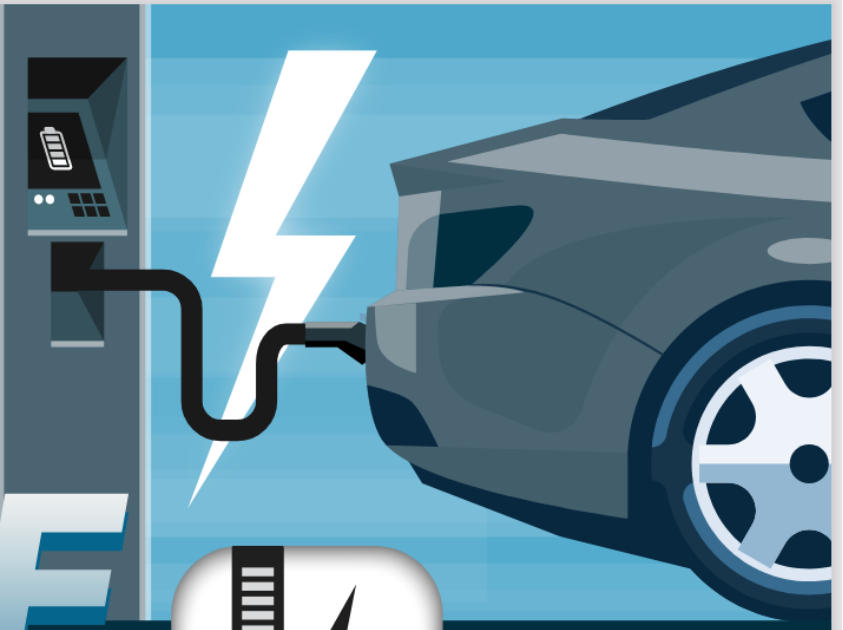
- www.NFPA.org
- www.evassociation.org Electric Vehicle Charging Association
- www.chargedevs.com. Charged Electric Vehicles Magazine
- www.IAEI.org (International Association of Electrical Inspectors)
- www.mikeholt.com
- www.esfi.org Electrical Safety Foundation International)
- https://www.nrel.gov/ National Renewable Energy Laboratories
- Multiple automobile and Class 2/DC Fast charger manufacturer websites

Always Lead with Safety!

CONNECTED to SAFETY

Understanding Electric Vehicles

Are you thinking about purchasing, or have you recently purchased an **electric vehicle**? Learn about the different charging options you have and how to **charge your electric vehicle safely**.



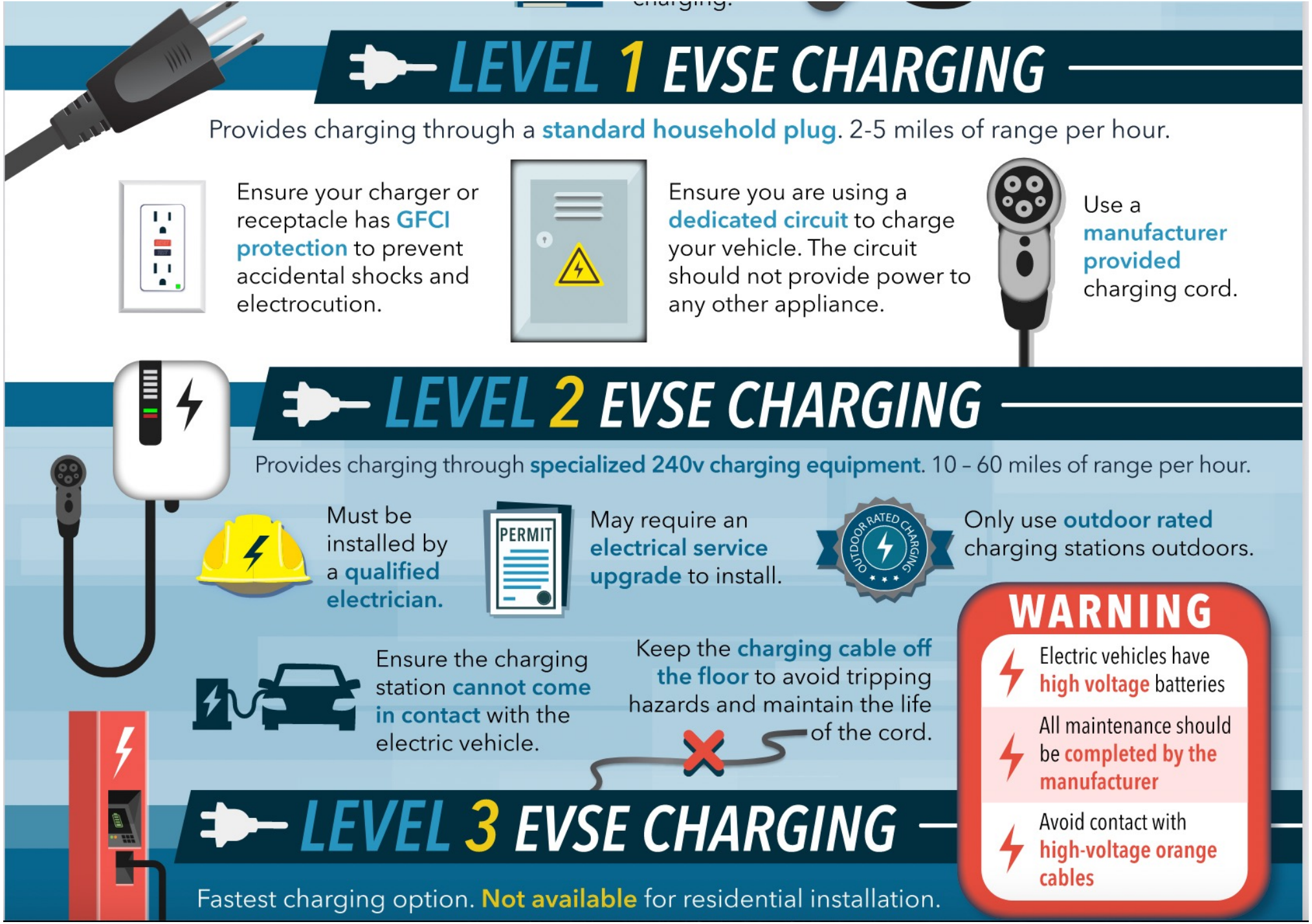
HOME CHARGING EVSE

Electric Vehicle Supply Equipment

Before using a charger, ensure the equipment has been listed by a **Nationally Recognized Testing Laboratory** (NTRL).

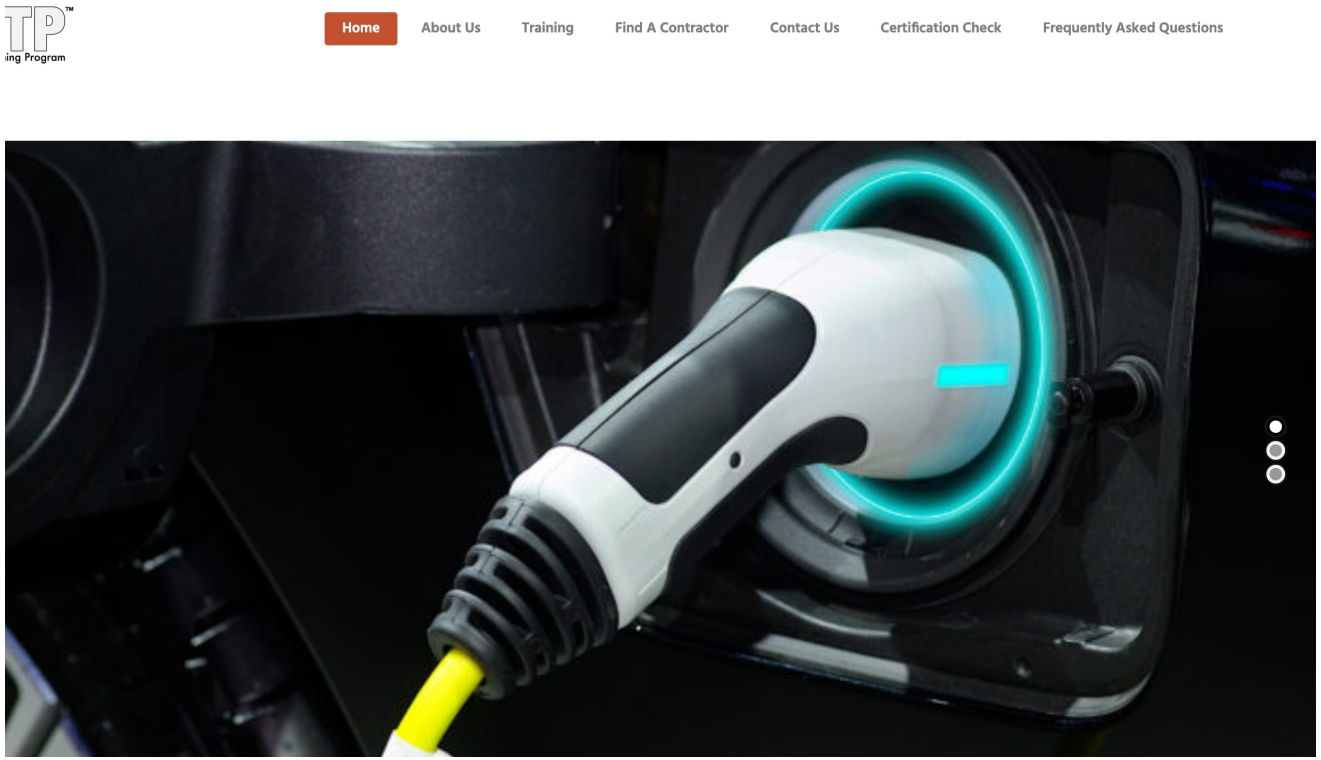
Have a **qualified electrician** inspect your home to ensure your electrical system can handle charging.

Ensure both the **charger** and **charging cord** do not have **damage** before use.



Courtesy ESFI.org

Electric Vehicle Infrastructure Training Program (EVITP)



- https://evitp.org/

2.2. Electric Vehicle Adoption in Ohio

Figure 3 show the concentration of EVs registered in Ohio. Logically, the highest concentrations of EVs are in the largest metropolitan areas of Cleveland, Columbus and Cincinnati – followed by Akron, Dayton, Toledo and Youngstown. Among these, the greatest acceleration has occurred in the Columbus region. This is due primarily to major consumer education campaigns through Smart Columbus and assisted by some rebates for government fleet purchases. Growth in other metro areas have also been assisted by "grassroots" education campaigns.

Over 40% of plug-in vehicles registered in Ohio are Tesla vehicles (see **Table 1**), all of which are fully battery electric (BEV). Thus, about 75% of the BEVs registered in Ohio are Teslas. Ohio has seen steady growth in electric vehicle sales and registrations. Consistent with national trends, Ohio EV sales have accelerated with the introduction of mid-market priced BEVs with battery pack ranges of over 200 miles.

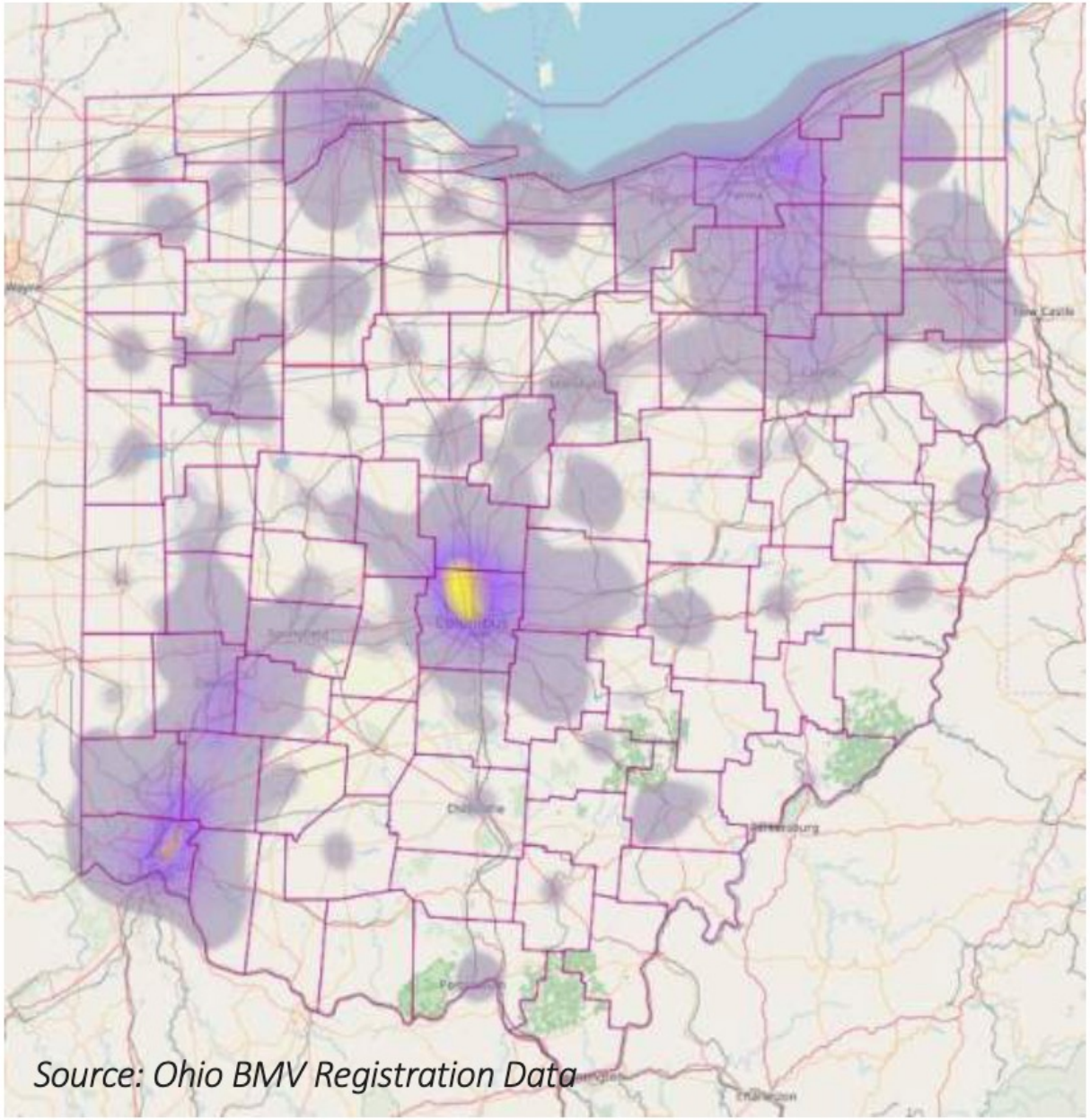


Figure 3: Ohio Concentration of Plug-In Vehicles


Review

Types of Electric Vehicles

- Hybrid Electric Vehicles (HEV)
- Plug-In Hybrid (PHEV)
- Plug-In Electric Vehicle (PEV)
- Battery Electric Vehicle (BEV)

Relevant NEC Chapters and Articles (Based on the 2020 NEC)

- **Article 625 Electric Vehicle Power Transfer Systems**
- Article 100 Key Definitions
- Article 110 Requirements for Electrical Installations
- Article 210 Branch Feeders - including GFCI requirements
- Article 215 Feeders
- Article 220 Branch-circuit, Feeder and Service Load Calculations
- Article 230 Services

Relevant NEC Chapters and Articles (Based on the 2020 NEC)

- Article 240 Overcurrent Protection
- Article 242 Overvoltage Protection
- Article 250 Grounding and Bonding
- Chapter 3 Wiring Methods and Materials
- Article 685 Integrated Electrical Systems
- Article 690 Solar Photovoltaic Systems

Relevant NEC Chapters and Articles (Based on the 2020 NEC)

- Article 702 Optional Standby Systems
- **Article 705 Interconnected Electric Power Production**
- Article 706 Energy Storage Systems
- Chapter 9 Tables

Other Resources

- NFPA 70E (2021) Electrical Safety in the Workplace
- NECA 413 Standard for Installing and Maintaining Electrical Vehicle Supply Equipment (EVSE)
- OSHA 1910 Subpart S Electrical Safety

UL and Other Standards

- **UL 2594** Electric Vehicle Supply Equipment
- **UL 2231** Personal Protection Device (i.e., CCID Hardware)
- **UL 1998** Standard for Safety-Related Software
- **UL 991** Standard for tests for Safety-Related Controls Employing Solid-State Devices
- **SAE J1772** Electric Vehicle Conductive Charge Coupler

NEC 705

- IEEE Std 2030.7-2017, *IEEE Standard for the Specification of Microgrid Controllers*,
- IEEE Std 2030.8-2018, *IEEE Standard for the Testing of Microgrid Controllers*, provide information on microgrid controllers.
- IEEE Std 1547-2018, *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*.

Residential Installations

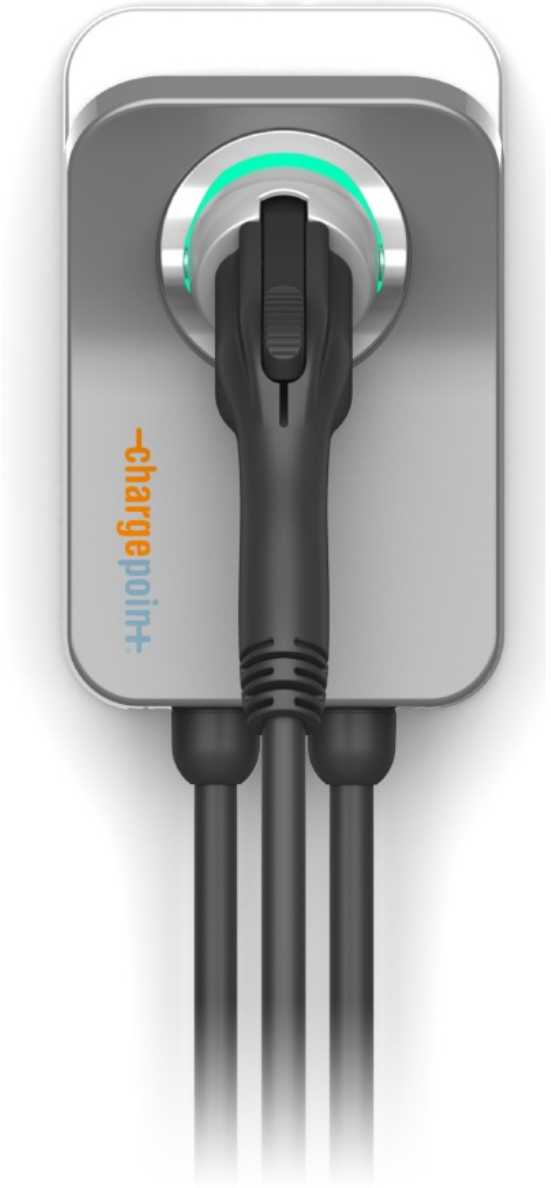
- Verify that equipment has proper listings: UL, ETL, CSA, TUV e.g.
  - Note: CE, RoHS, ISO 9000 etc. are not acceptable in the US!
- Read all manufacturer instructions!
- Follow all grounding and bonding requirements from manufacturer and the NEC
- Do not install in a hazardous location unless the equipment is rated for the location (Class I, Division 2, Class II, Division 2 for example)
  - See NEC chapter 5
- Inspect equipment for damage prior to installation

Residential Installations

- Use recommended wire type and material (90 deg C, copper) for example
- Make sure charger will be operating within its temperature range
  - Verify in extreme hot and cold locations
- Determine whether charger will be installed indoors or outdoors
  - Verify equipment is rated for outdoor, wet or damp locations if installed outdoors

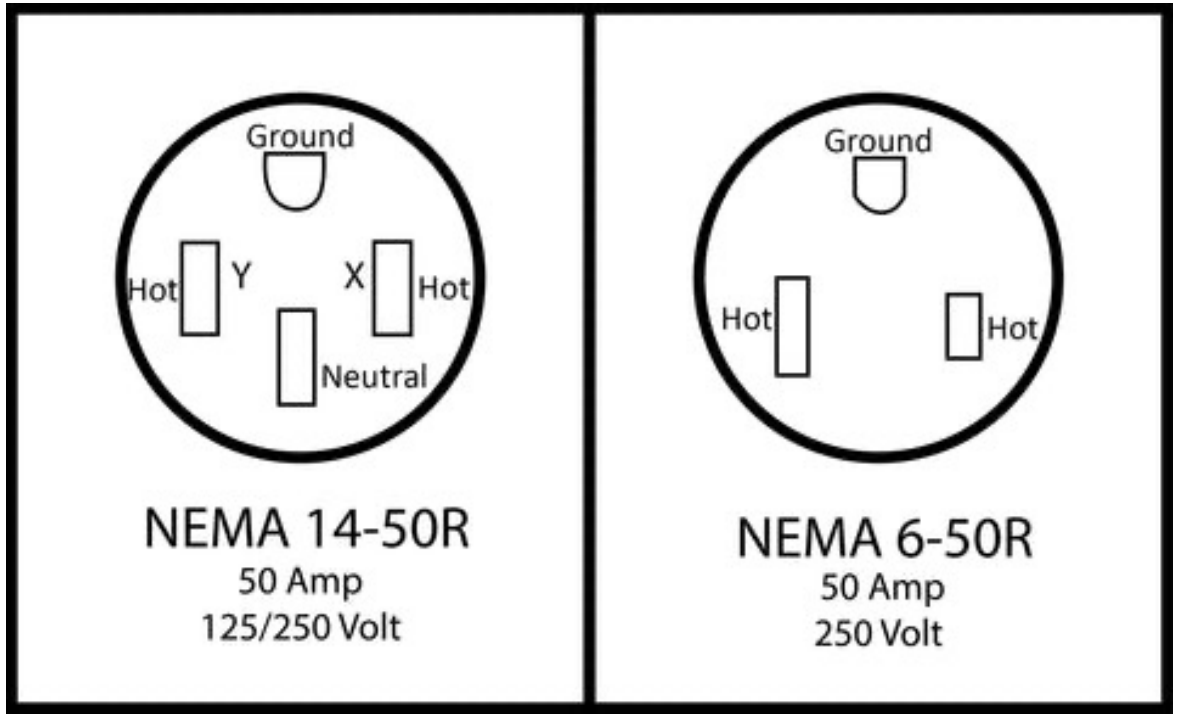
Example:

ChargePoint HomeFlex, 16A-50A Flexible Amperage Charger



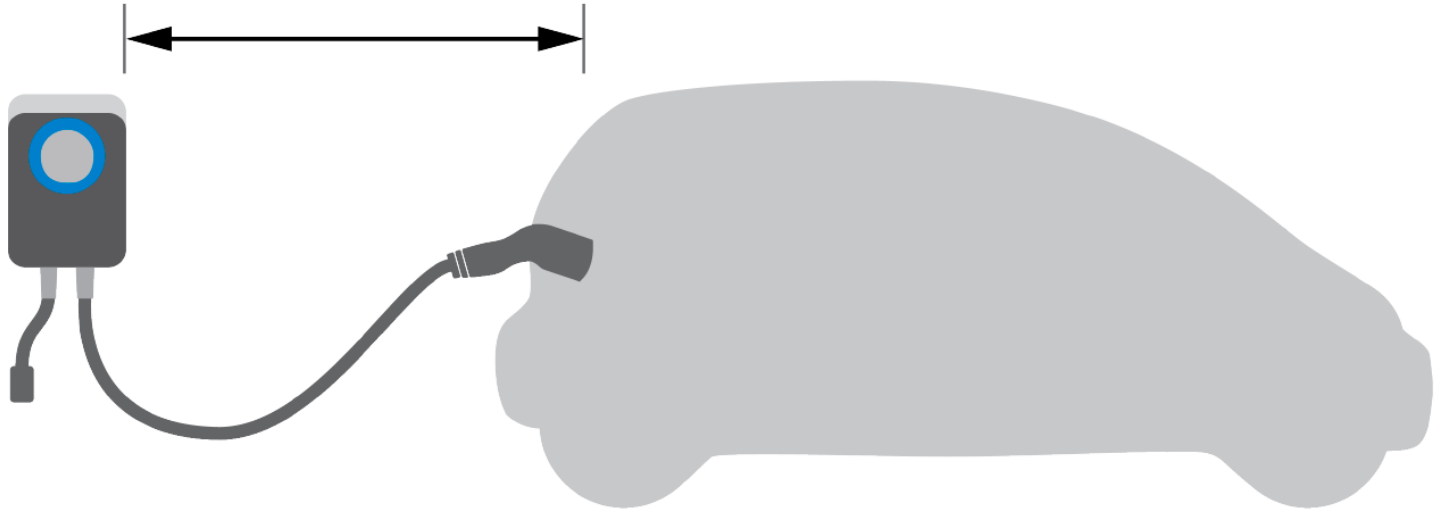
Options

- Use one NEMA 14-50 or NEMA 6-50 Outlet
- Fastened in place equipment shall be connected to the premises wiring by one or more of the following methods per 625.43(B) Fastened In-Place Equipment



Installation

- Choose an installation location that allows the charging cable to reach the car’s charging port while still providing slack
- Ensure a stud is available for mounting the charger
- Ensure a reliable WiFi signal is available

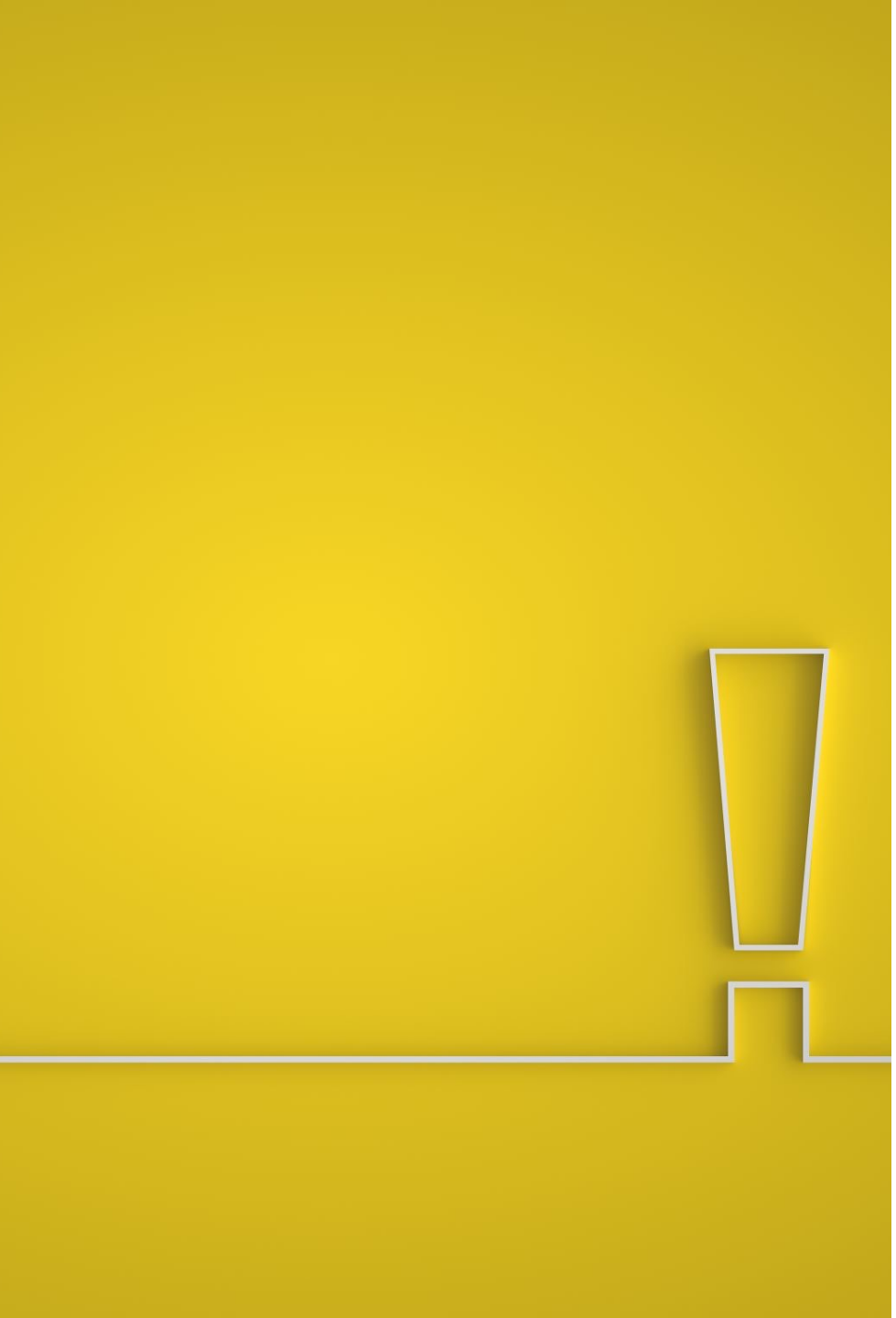


Outdoor Installation Option

- Requires outdoor –rated weather-resistant electrical outlet per 625.56
- Or hardwired installation

A *plug-connected charging station* must be installed close to the outlet. The image above shows how a *plug-in HCS model* could be installed outdoors. Note the weather-proof outlet covering.

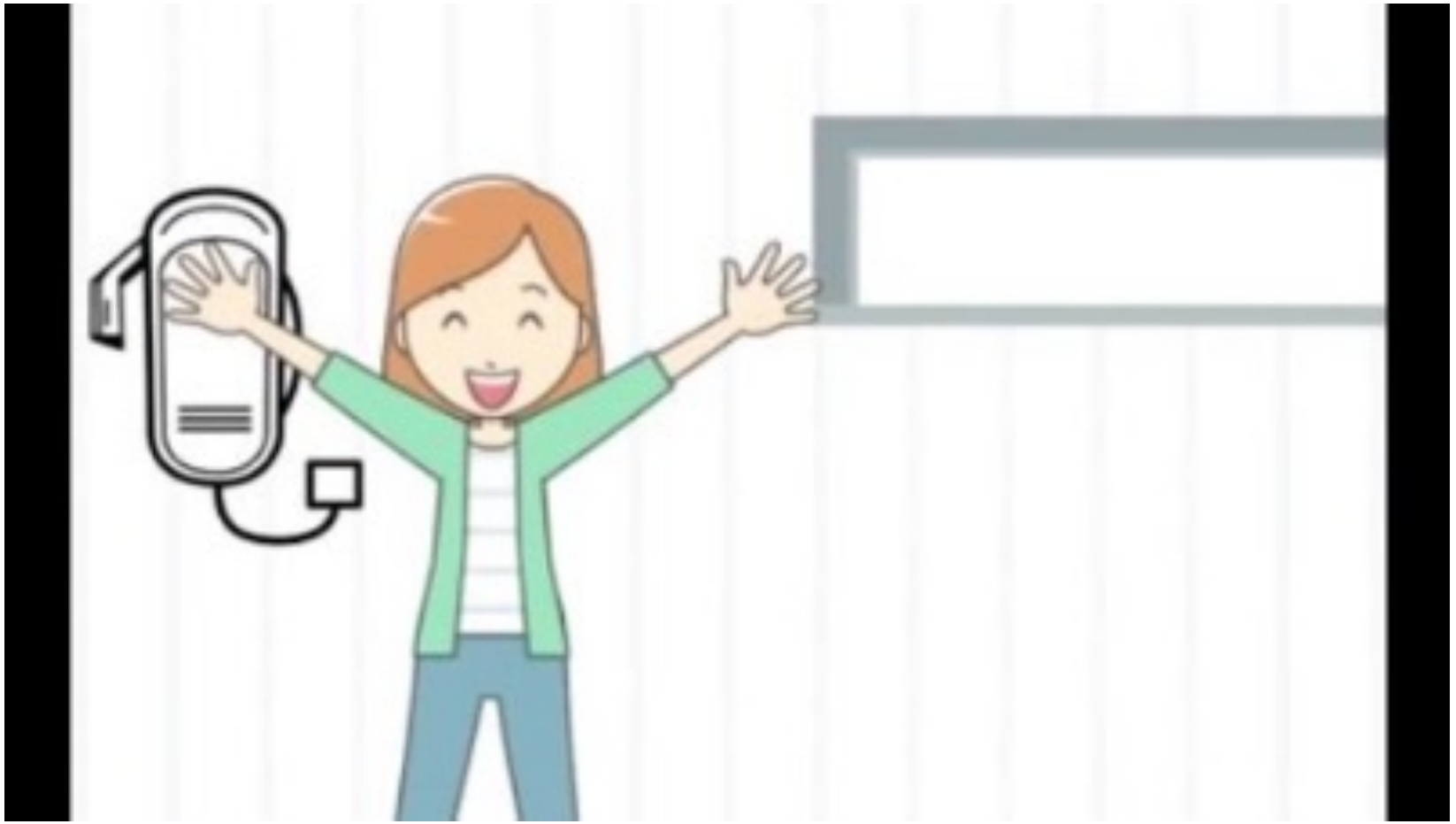
A *hardwired charging station* can be installed indoors or outdoors, but is always recommended for any given outdoor installations. Notice the conduit coming from the bottom of the hardwired HCS model and the ridged cord.

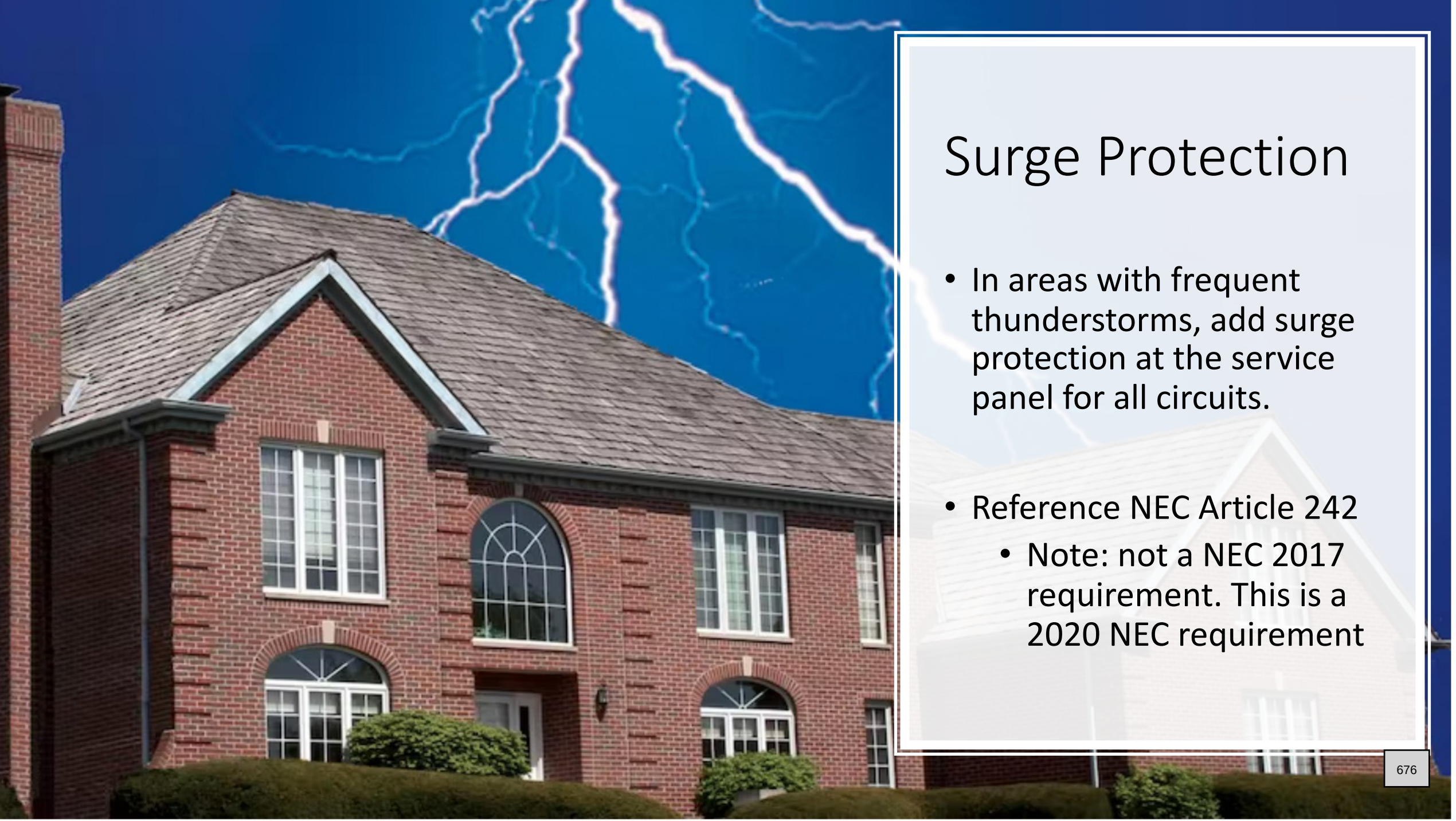


625.56 Receptacle Enclosures

- Receptacles for EV charging in a wet location shall be installed in a weatherproof enclosure
- Outlet box hood for the WP enclosure shall be listed and identified for Extra Duty
- If the the enclosure or assembly does not include a hood, it is not required to be marked as Extra Duty

Hardwire or Plug-In Installation?





Surge Protection

- In areas with frequent thunderstorms, add surge protection at the service panel for all circuits.

- Reference NEC Article 242
  - Note: not a NEC 2017 requirement. This is a 2020 NEC requirement

Determine Required Charging Amps

- Check electrical panel available space
- Check electrical service available capacity
- Important! Chargers are considered a Continuous load
- Multiply rated amps x 125% (1.25) per NEC 625.41

625.41 Overcurrent Protection (Circuit Breakers or Fuses)

- Overcurrent protection for EVSE and WPTE equipment shall be sized for continuous duty (125%)
- Shall have a rating of not less than 125% of the maximum load of the equipment.
- Use nameplate data to determine maximum rating
- Where noncontinuous loads are supplied from the same feeder, the overcurrent device shall have a rating of not less than the sum of the noncontinuous loads plus 125 percent of the continuous loads.

Determine Required Charging Amps

- Charge controller can be installed at a variety of amperages
- Determine if homeowner prefers plug-in or hard-wired installation

CAUTION: Home Flex is a continuous load device. The circuit must be rated for 125% of the maximum load.

Circuit Rating	Max Load	Estimated Range per Hour	Plug-In	Hardwire
50 A	40 A	30 miles/48 km	yes	yes
40 A	32 A	25 miles/40 km	yes	yes
30 A	24 A	18 miles/29 km	no	yes
20 A	16 A	12 miles/19 km	no	yes

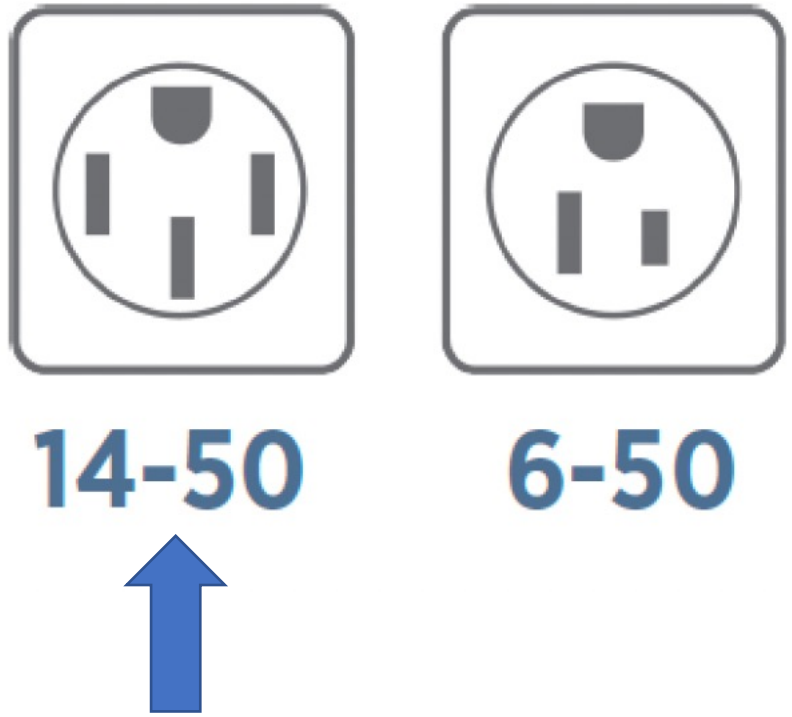
Higher Charging Amps

- This unit is capable of charging at higher amps
- Check electrical service to determine if adequate supply is available

Circuit Rating	Max Load	Estimated Range per Hour	Plug-in	Hardwire
80 A	50 A	37 miles/60 km	no	yes
70 A	50 A	37 miles/60 km	no	yes
60 A	48 A	36 miles/58 km	no	yes

Determine Appropriate Outlet and NEMA Receptacle Size

For single phase 240V application
- Hot (L1)
- Hot (L2)
- Neutral
- Ground



Required for this installation

For single phase 120V application
- Hot
- Neutral
- Ground

Electrical Service

- Ensure the panel can accept a 2-pole, 240-volt circuit breaker
- Ensure this will be a dedicated circuit per 625.40
  - *Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit. Each circuit shall have no other outlets.*

625.54 Ground-Fault Circuit-Interrupter Protection for Personnel

- Portable and fastened-in-place EVSE that is permitted to be cord-and plug-connected must be supplied through a GFCI-protected receptacle.
  - *Henry's take: As far as I know, I have not seen any NEMA 14-50 GFCI receptacles, therefore, this must be a GFCI breaker at the panel (2-pole, 240V)*
  - *Amperage to be determined later*

- What about hard-wired installations?

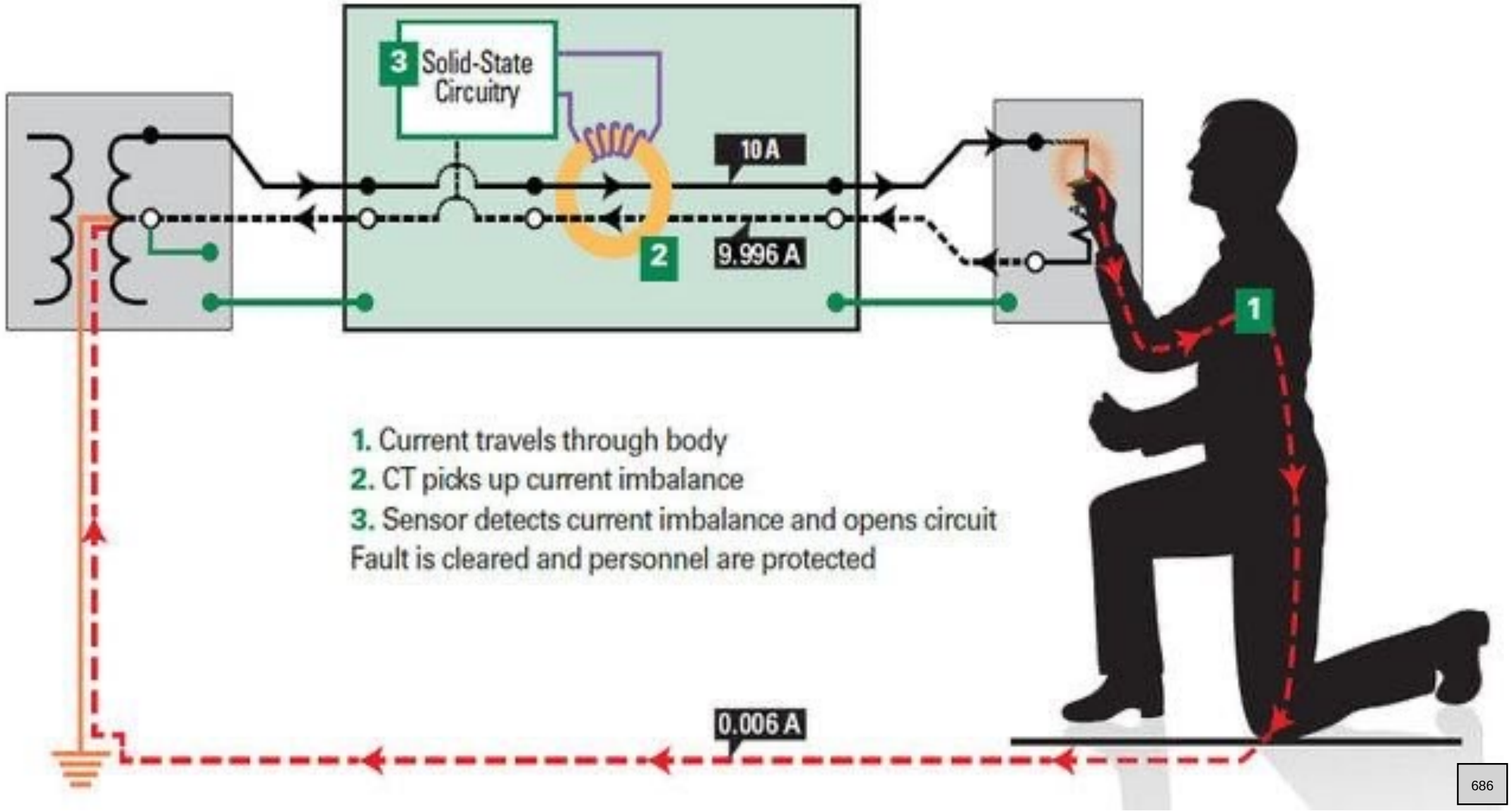
625.54 Ground-Fault Circuit-Interrupter Protection for Personnel

- The outlet supplying direct-connected EVSE is not required to be GFCI protected unless specified in the manufacturer's instructions.

- *Henry's note: Many manufactures have built-in GFCI or shock protection*

Remember

- Per the NEC, GFCI's are required for
  - Garages *per 210.8(A)(2)*
  - Outdoor installations *per 210.8(A)(3)*
  - NEW for 2020 NEC: installations rated 150 VAC to ground or less. This includes 208V (120 volts to ground) and 240 V (120 volts to ground) installations *per 210.8(A)*


3 Solid-State Circuitry
10 A
2
9.996 A
1
1. Current travels through body
2. CT picks up current imbalance
3. Sensor detects current imbalance and opens circuit
Fault is cleared and personnel are protected
0.006 A

From Clipper Creek…

- With a hardwired charging station **you generally do not need to have a GFCI circuit breaker in place** whereas you would be required to have this for any 240V outlet used for an electric vehicle charging station per National Electric Code requirements.

From Clipper Creek…

- Using a GFCI breaker to supply a charging station can result in nuisance tripping of the breaker during charging. The trip threshold for a standard U.S. GFCI breaker is 5mA which is relatively low for electric vehicle charging. For comparison, charging stations have 20mA GFCI protection built it. At the 5mA trip threshold you may experience nuisance tripping of the circuit breaker during charging due to noise on the line generated by the vehicle.

Per the 2020 NEC…

625.54 Ground-Fault Circuit-Interrupter Protection for Personnel.

In addition to the requirements in **210.8**, all receptacles installed for the connection of electric vehicle charging shall have ground-fault circuit-interrupter protection for personnel.

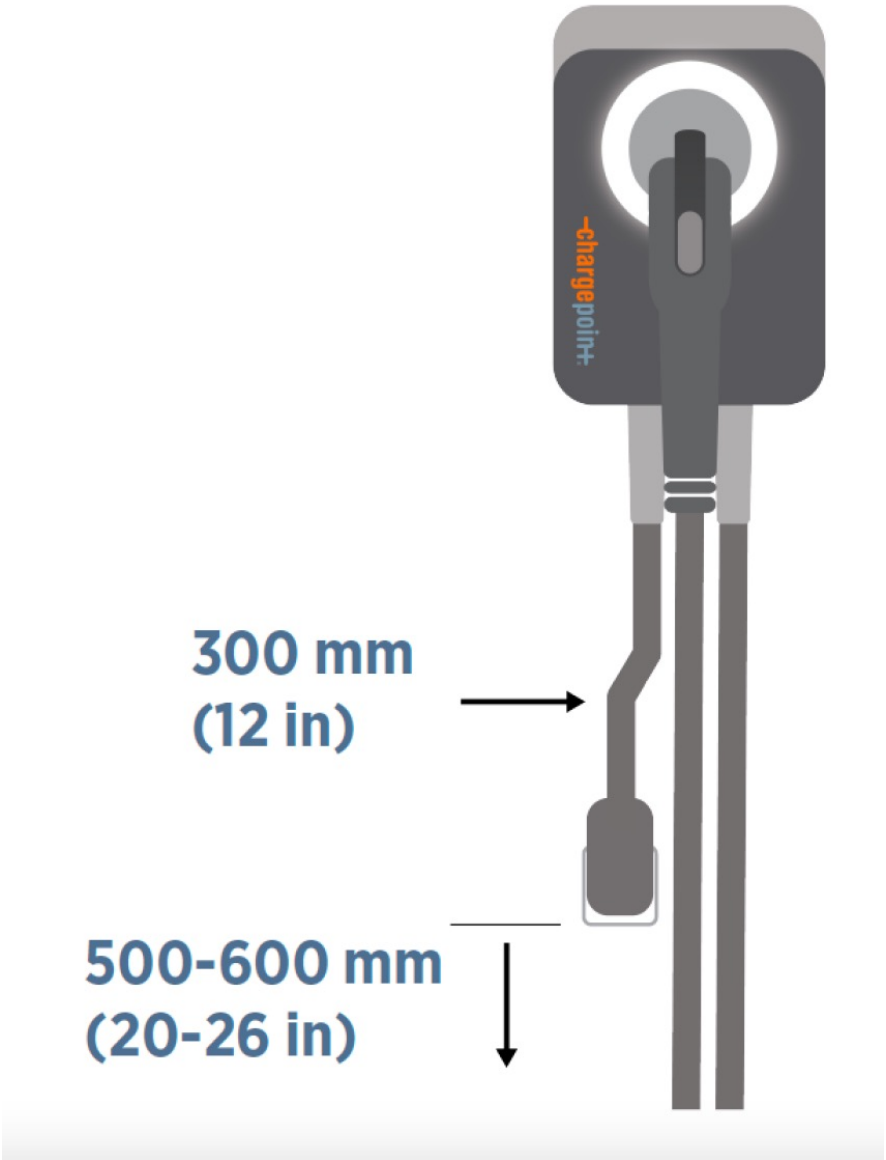
ENHANCED CONTENT

Collapse

Portable and fastened-in-place EVSE that is permitted to be cord-and plug-connected must be supplied through a GFCI-protected receptacle. This includes all the single- and three-phase receptacle configurations specified in **625.44**(A) and (B). The outlet supplying direct-connected EVSE is not required to be GFCI protected unless specified in the manufacturer's instructions.

Mounting

- For plug-in applications, the outlet should be located 20-26 inches from the ground
- Note: The input cable is 12 inches long per the NEC



625.50 Location

- Minimum mounting height for fixed or fastened-in-place EVSE coupling connectors (cabling and connectors)
- Not less than 18 inches above the floor for indoor locations
- Not less than 24 inches above the grade for outdoor locations

Details

240/120 Volt, 200-amp existing service

100 amps of existing load

Several spaces in panel available

Decide to use 40 amp charging (40 rated amps)

Uses 50-amp circuit per instructions

Installing inside of the garage

Plug-in installation*

*GFCI protection required

NEMA 14-50 receptacle

Using NM (Romex) cable, no conduit

Example Calculations: Residential Single Phase

- Can the existing panel handle the new load?
- What size overcurrent protection is required?
- What size wire is required for feed the charger?
- Is voltage drop acceptable?

Example Calculations: Residential Single Phase

- Charger rated 240 VAC, 40 amps, 9600 watts
- Since EVSE (chargers) are considered a continuous load:
  - 40 x 1.25 = 50 Amps
- Existing service has 100 amps of load existing (max demand)
  - 100 + 50 = 150 Amps
  - Yes, the 200 amp panel can handle the additional EVSE load

Calculate Wire Size

- Since EVSE is a continuous load: 40A x 1.25 = 50 amps
- Size wire size for 50A

334.80 Ampacity.

The ampacity of Types NM and NMC cable shall be determined in accordance with **310.14**. The ampacity shall not exceed that of a 60°C (140°F) rated conductor. The 90°C (194°F) rating shall be permitted to be used for ampacity adjustment and correction calculations, provided the final calculated ampacity does not exceed that of a 60°C (140°F) rated conductor. The ampacity of Types NM and NMC cable installed in cable trays shall be determined in accordance with **392.80(A)**.

Final Design

- 60 amp, 2-pole, 208V CB (non-GFCI)
- Hardwired (no receptacle or plug)
- (2) #2 THWN-2 and (1) #4 THWN-2 EGC in ¾” RMC

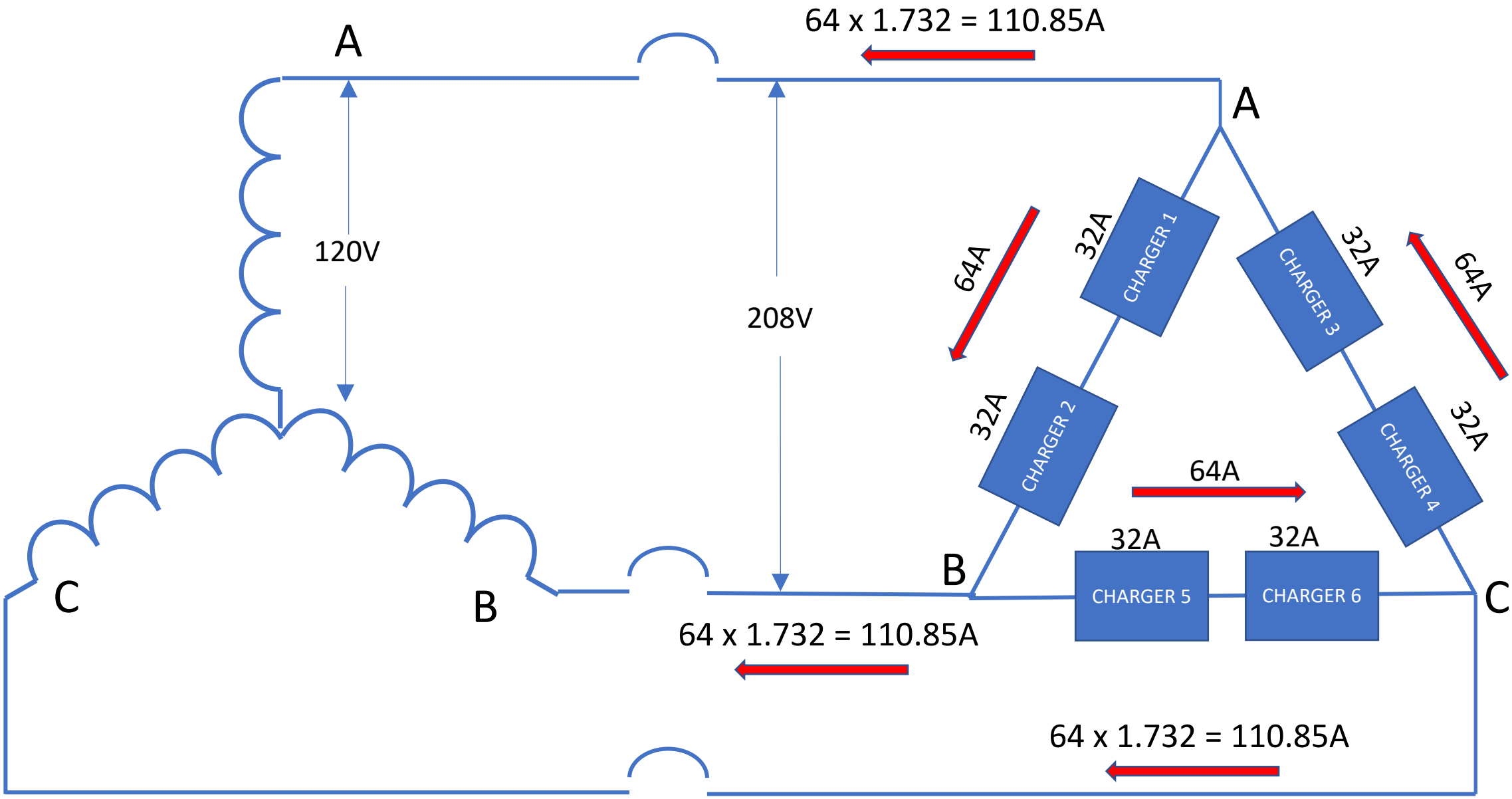
Three Phase Example

- What is the minimum size 120/208 V, three –phase OCPD and THWN-2 CU feeder required to supply 6 CS-40 chargers?
- Assume all equipment is rated 75 deg C
- Assume load is balanced
- For 6 chargers, there will be 2 chargers on each phase to balance the load

Example

- One charger draws 32 A.
- Power for one charger = 32 x 208 = 6656 VA (Watts)
- For 6 chargers, total power = 6656 x 6 = 39,936 VA (Watts)
- 3-phase power equation: P = 1.73 x V x I
- I = P/(1.73 x V) = 39,936/(1.732 x 208) = 110.85 A
- Since loads are balanced, there will be 110.85 amps on each phase
- Since chargers are continuous loads, multiply current by 125% for OCPD and wire size calculations

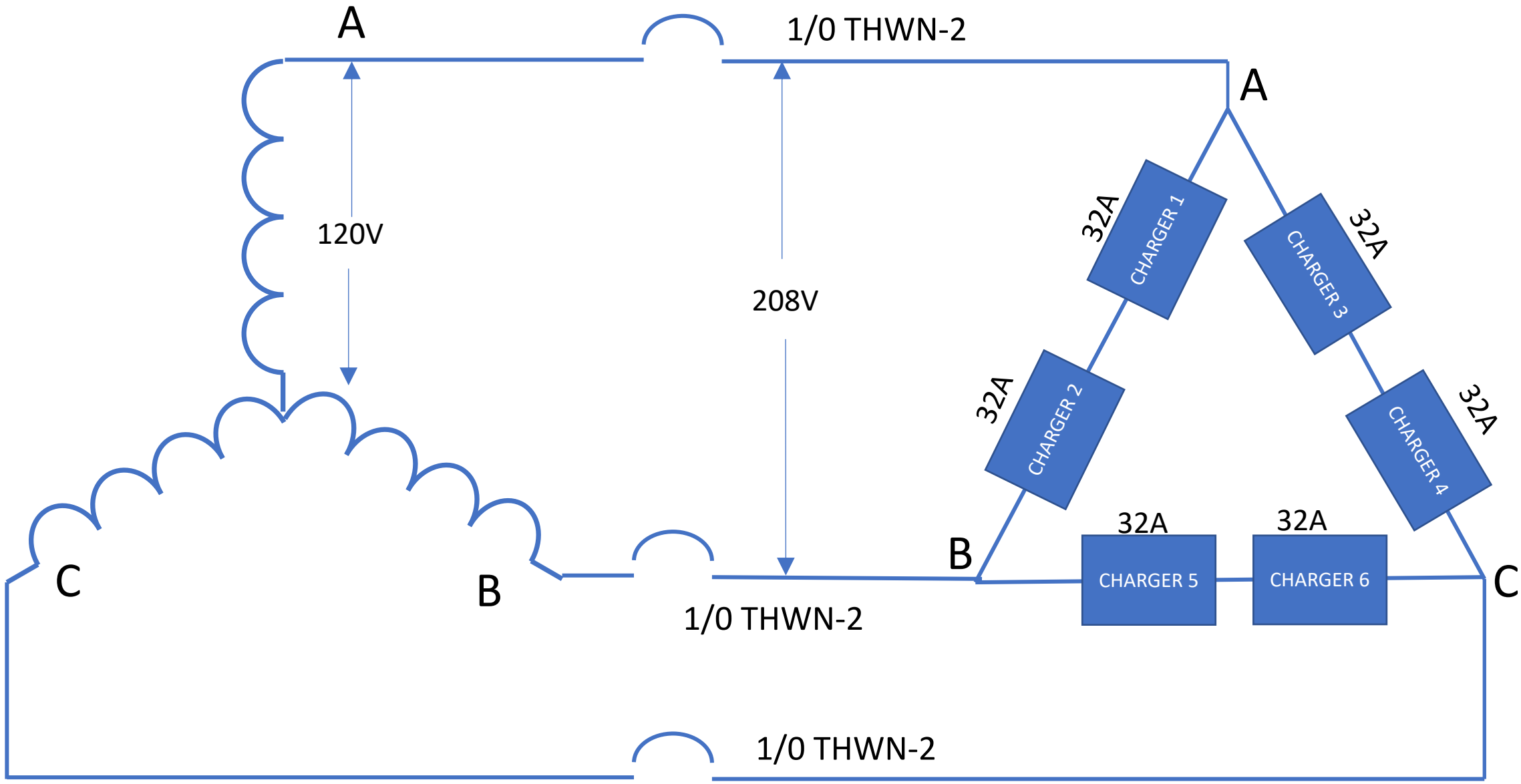
400A Service



Determine Wire Size

- Multiply line currents by 125%
- 110.85 x 1.25 = 138.57 A
- 1/0 THWN-2 wire is good for 150 A @ 75 deg. C

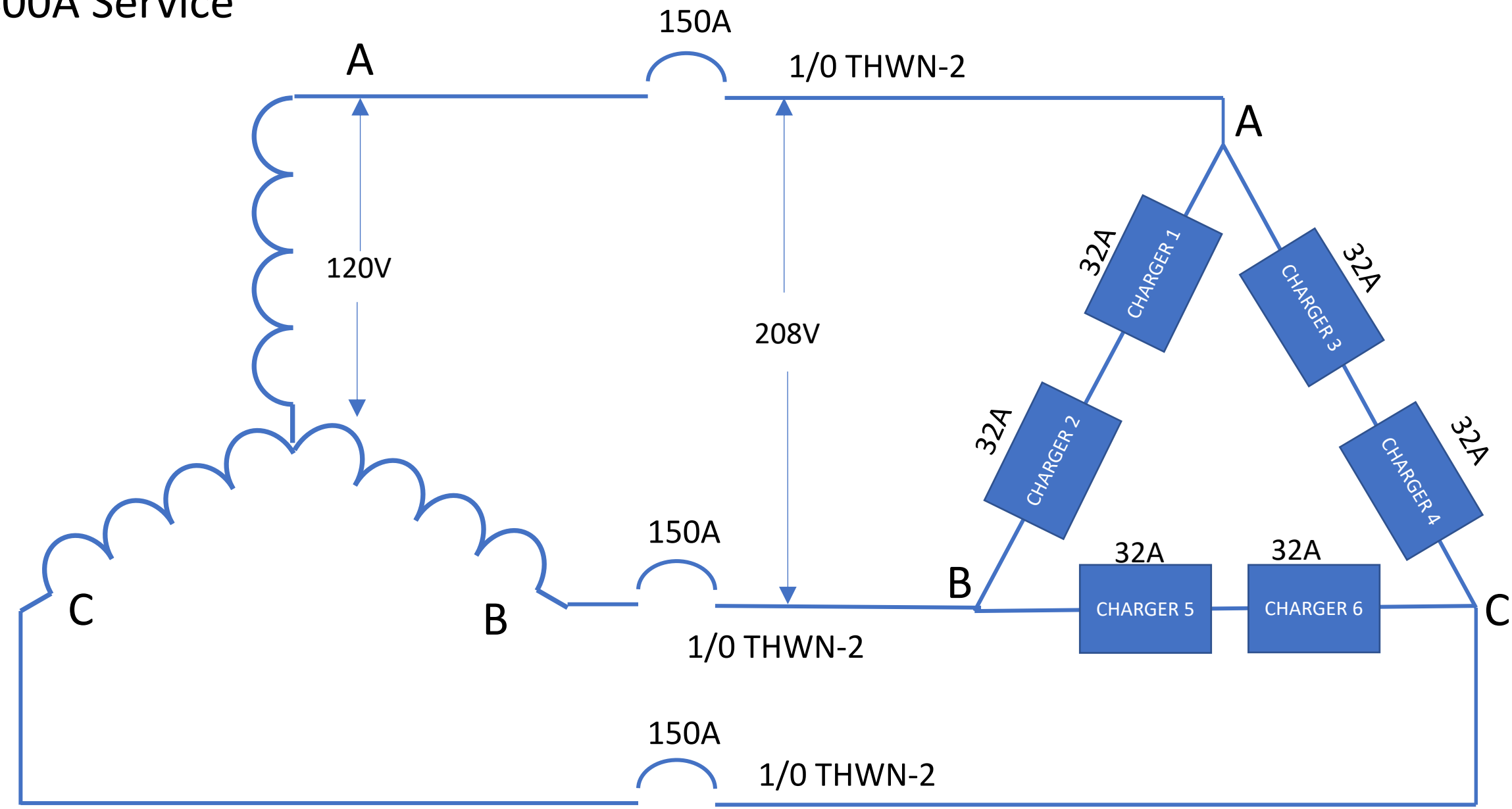
400A Service



Determine Overcurrent Protection Size

- Multiply line currents by 125%
- 110.85 x 1.25 = 138.57 A
- There is no standard CB for 138.57 A, so OK to use next size up
- 150A CB

400A Service



Can 150A CB Protect 1/0 Wire?

- 1/0 THWN-2 wire at 75 deg C is good for 150A
- Yes, 150A circuit breaker can protect 1/0 wire

Other Adjustment Factors to Consider

- Number of wires in conduit
- Ambient temperature
- Voltage Drop

Follow up question…

- If this 400 A service already had 200A of load on it, can it accept the new charger loads?
- New load is 32A/charger x 6 chargers = 192 amps
- Since chargers are considered a continuous load, have to add 125%
- 192 x 1.25 = 240A
- 200 amps of existing load + 240 amps of new load = 440 amps
- No! The service cannot accept the new load!
- Would need to:
  - install a larger service
  - Decrease existing load
  - Or select lower wattage chargers!

Other Considerations for Commercial Installations

- Placement of chargers: Charging for one car or two
- Protection of chargers: bollards, concrete curbs etc.
- Access to chargers
- Protection of cables
- Theft of cables
- Physically Impaired driver access: ADA compliance
- Lighting of areas
- Water Drainage

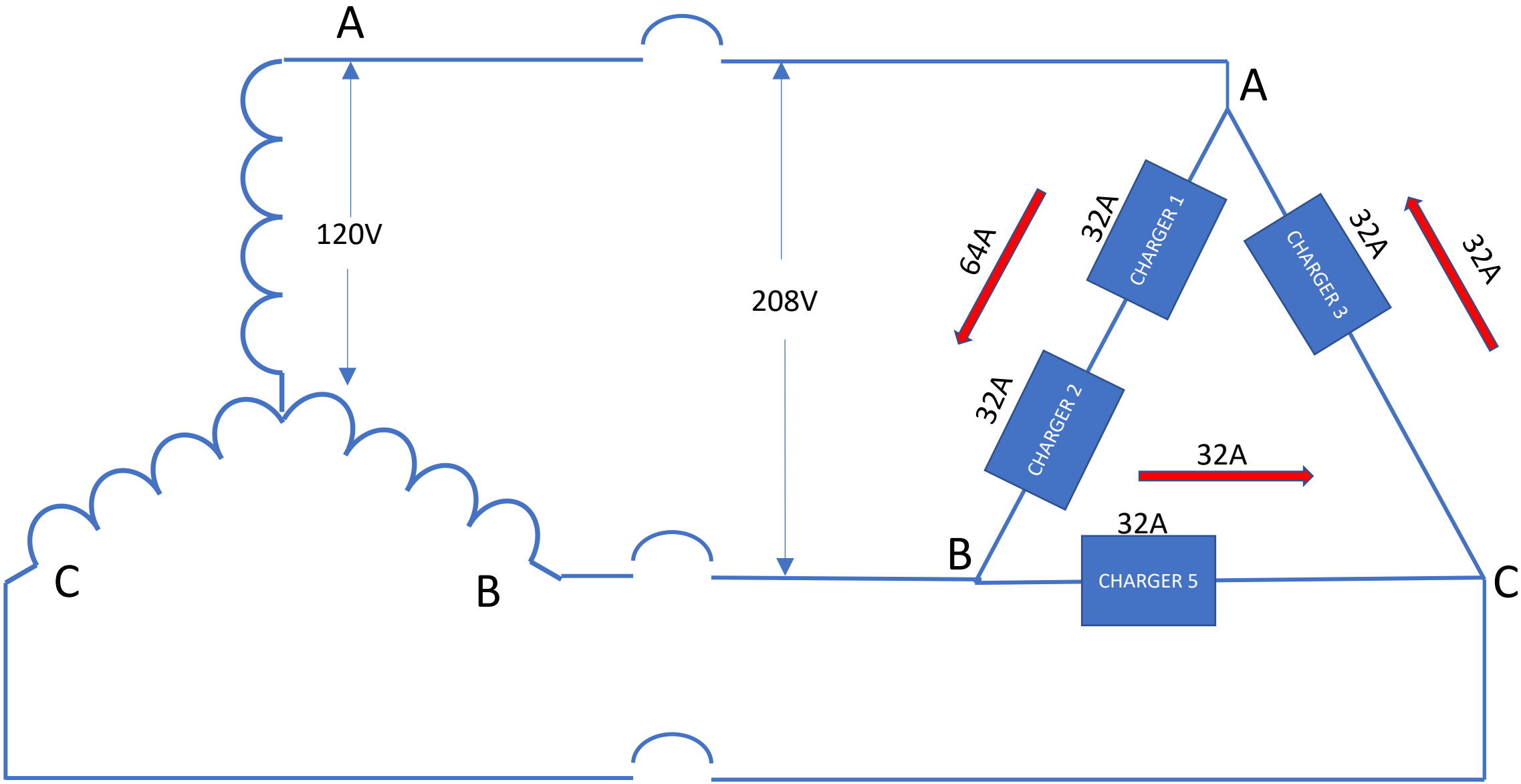
Warning! Uglier Math Ahead!

Challenges

- Unbalanced loads
- Long feeder distance to charger - voltage drop
- Hardwire installations
- If using parallel feeds: avoiding inductive heating
- Must consider neutral current due to line imbalance (if using neutral)
- Circuit Breaker selection

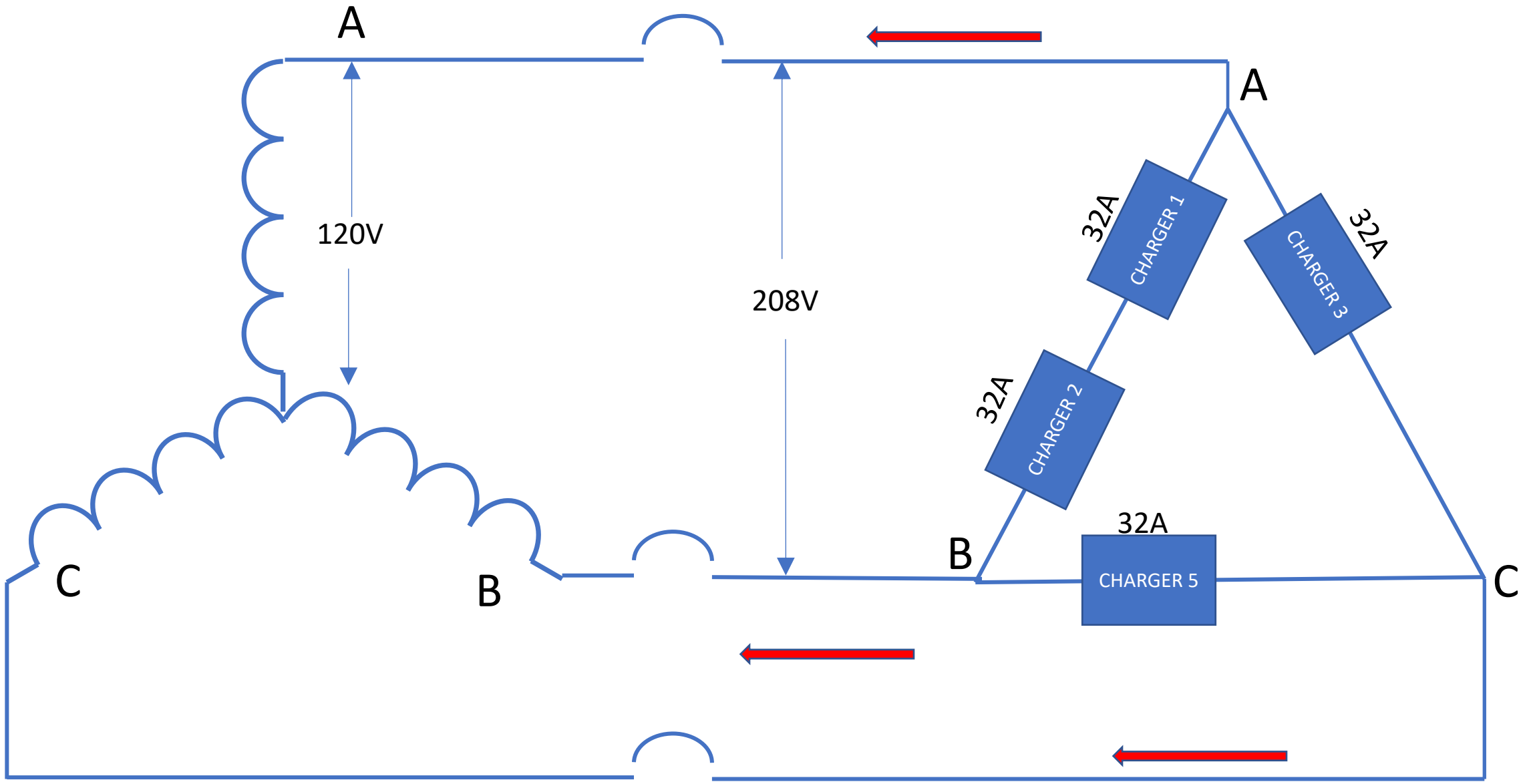
400A Service

Determine Phase Currents



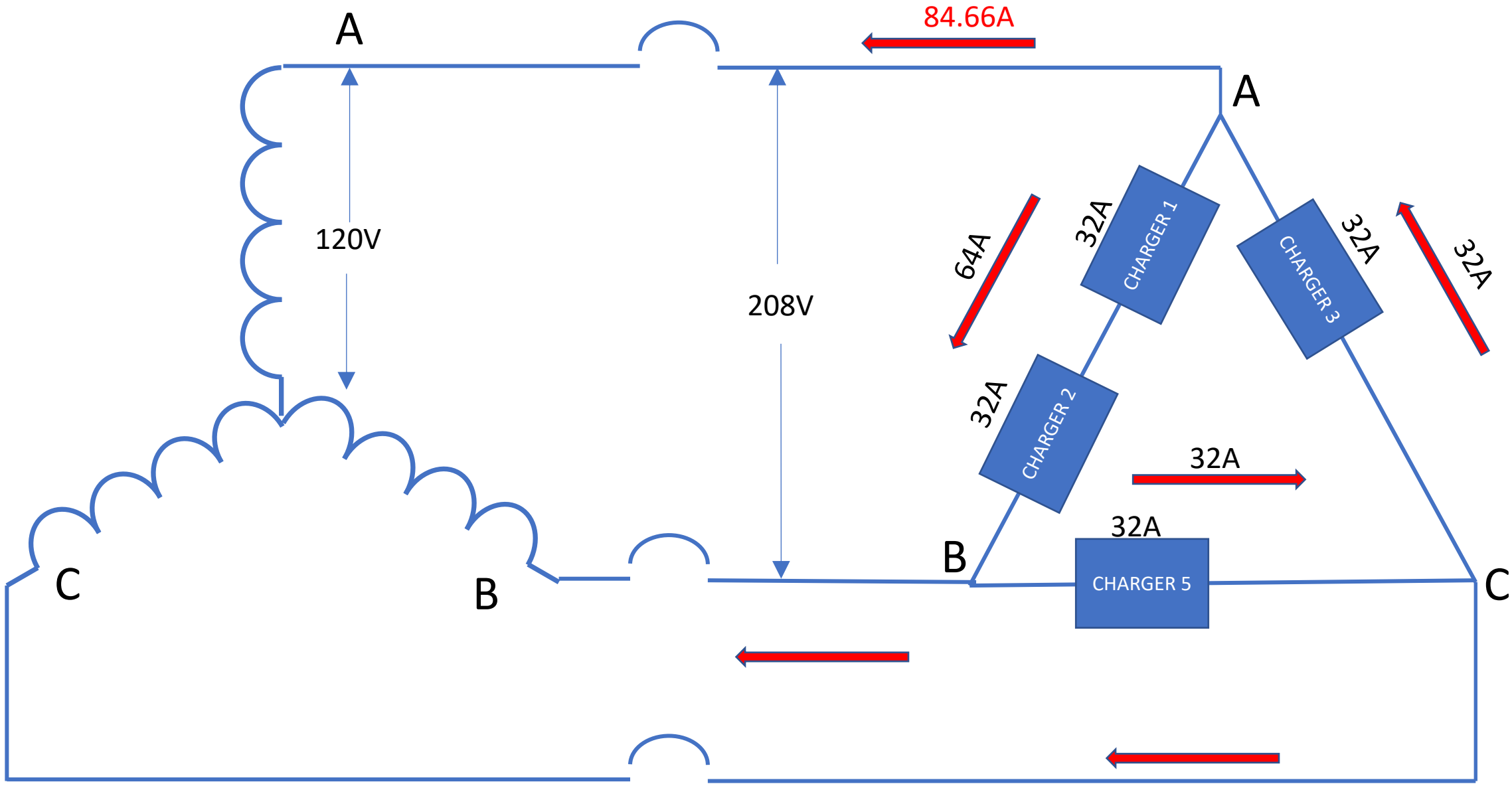
400A Service

Determine Line Currents



400A Service

Determine Line Currents



CONGRATULATIONS!

Next Steps

A Certificate of Completion will be emailed to those who successfully completed course

4 hours of Code Class Hours will be reported to the OCILB for Code Continuing Education Credits

Contact instructor at hpmatthews@matthewselectrical.net for any questions or comments

Make sure you completely sign out of webinar after the next slide!

File Attachments for Item:

EC-10 Ever-Changing Structural Provisions of Our Building Codes: Wind (ICC)

All certifications (2 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Ever-Changing Structural Provisions of Our Building Codes-Wind

Course instructor: Dr. S. K. Ghosh

Course description: "This seminar is about major, far-reaching changes in the wind provisions of U.S. codes and standards over the last three decades or so. This will include the very substantive changes in wind design provisions from ASCE 7-16 to ASCE 7-22, which are reflected in the IBC. ~~This is a chance to review where we have been and gives us an appreciation of the present with the insight of someone who has~~ long been intimately involved in the structural code development process.

changes.

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: May 1, 2023 Tampa, FL

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

x Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Ever – Changing Structural Provisions of Our Building Codes

Description

This seminar is about major, far-reaching changes in the wind provisions of U.S. codes and standards over the last three decades or so. This will include the very substantive changes in wind design provisions from ASCE 7-16 to ASCE 7-22, which are reflected in the IBC. This is a chance to review where we have been and gives us an appreciation of the present with the insight of someone who has long been intimately involved in the structural code development process. The major topics covered are:

- An Overview of the History and Development of Wind Provisions
- ASCE 7-16 to ASCE 7-22: Substantive Changes to Wind Design Provisions

Learning Objectives

1. Get an overview of wind load provisions in ASCE 7-22.
2. Learn about significant changes in ASCE 7 wind provisions over various editions of ASCE.
3. Learn the implications of the changes in ASCE 7-22 in wind load determination.
4. Discover the challenges a practicing engineer may face following ASCE 7-22 wind load provisions.

Outline of Seminar **(2 hours = 120 minutes)**

3:00 PM – 5:00 PM

I. Ever-Changing Structural Provisions of Our Building Codes – Wind (120 minutes)

- I. ASCE 7 wind design provisions prior to ASCE 7-95
- II. ASCE 7 wind design provisions from ASCE 7-98 to ASCE 7-16
- III. Changes in wind design provisions from ASCE 7-16 to ASCE 7-22
- IV. Discussion

Please allow for breaks at natural intervals

Instructor Bio: Dr. S.K. Ghosh, PhD

Dr. Ghosh is a former member of the Boards of Direction of ACI, the Earthquake Engineering Research Institute (EERI) and BSSC (Building Seismic Safety Council). He is a member of the Board of Governors of ASCE's Structural Engineering Institute. Ghosh has long been a provider of continuing education related to structural provisions of building codes to the structural engineering profession and the code enforcement community. His books and other publications on structural design are widely used by those in design practice. In addition to authoring over 200 papers and books, Dr. Ghosh has investigated and reported on structural performance in most recent earthquakes. Among his many awards, on the 50th anniversary of the Precast/Prestressed Concrete Institute (PCI) in 2004, S. K. Ghosh was named one of fifty "Titans" of the U.S. Precast/Prestressed Concrete Industry. He was awarded ASCE's 2013 Walter P. Moore Jr. Award for his contributions towards improving the consistency, accuracy and clarity of structural codes and standards throughout the U.S. and abroad. Ghosh has a Bachelor of Engineering (BE) in civil engineering from the University of Calcutta, India, and a Master of Applied Science (MASc) and Doctor of Philosophy (Ph.D.) in structural engineering from the University of Waterloo, Ontario, Canada.

Ever-Changing Structural Provisions of Our Building Codes - Wind

S. K. Ghosh

S. K. Ghosh Associates LLC

Palatine, IL

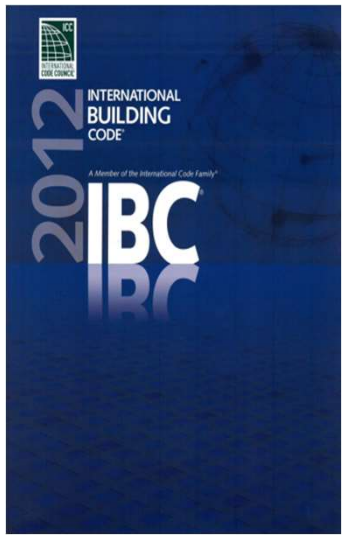
www.skghoshassociates.com

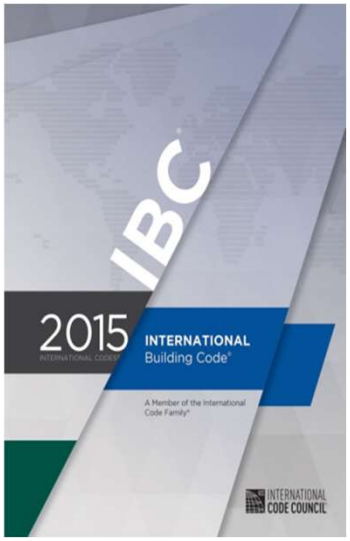
720

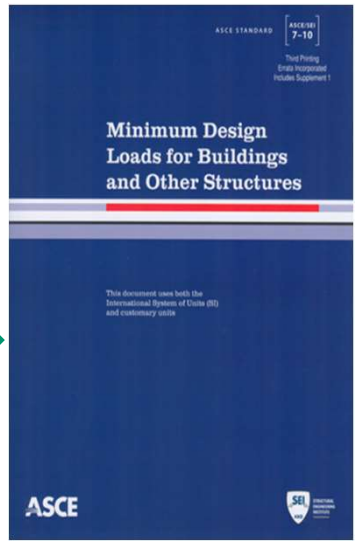
IBC Structural Provisions

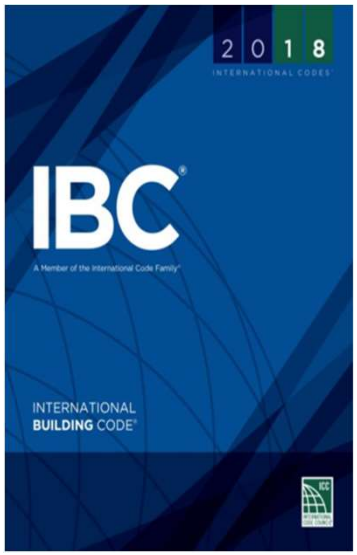
Big changes in IBC structural provisions occur when a new edition of ASCE 7 is adopted by the IBC

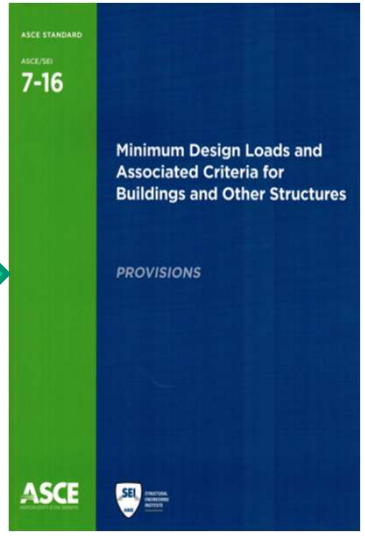
IBC Structural Provisions











Design Load Standards

1. ANSI A58.1-1972
2. ANSI A58.1-1982
3. ASCE 7-88
4. ASCE 7-93
5. ASCE 7-95
6. ASCE 7-98
7. ASCE 7-02
8. ASCE 7-05
9. ASCE 7-10
10. ASCE 7-16

Note: Only seismic provisions changed between ASCE 7-88 and ASCE 7-93

WIND

Background

- Wind Loading is the effect of the atmosphere passing by a stationary structure attached to the earth's surface.
- Wind Loads are controlled by Atmospheric and Aerodynamic effects.
- The 3 terms in the general equation of wind:
  - Velocity Pressure, q - Atmospheric Effects.
  - External Pressure Coefficient, C_p – Aerodynamic Effects.
  - Gust Effect Factor, G - Combination of both.

$$p = q \times G \times C_p$$

Atmospheric Effects

- Meteorological Effects
- Boundary Layer Effects

Meteorological Effects

- Meteorology provides a description and explanation of the basic features of atmospheric flows.
- Climatology deals with the prediction of storm conditions at a given geographic location.

Climatological Effects

- Thunderstorms.
- Tornadoes.
- Hurricanes.
- Special Regional Effects.

Thunderstorms

- Variety of associated wind phenomena.
- Predicted thunderstorm activity controls vast majority of US wind loads.
- Reason most of the inland U.S. has the same or very similar design wind speeds.

Tornadoes

- Design wind speeds do not include the effects of tornadoes.
- Probability of occurrence at a particular location so low that tornadoes do not appear in the 50-year statistical storm data used to formulate the inland portion of the map.

Tornadoes

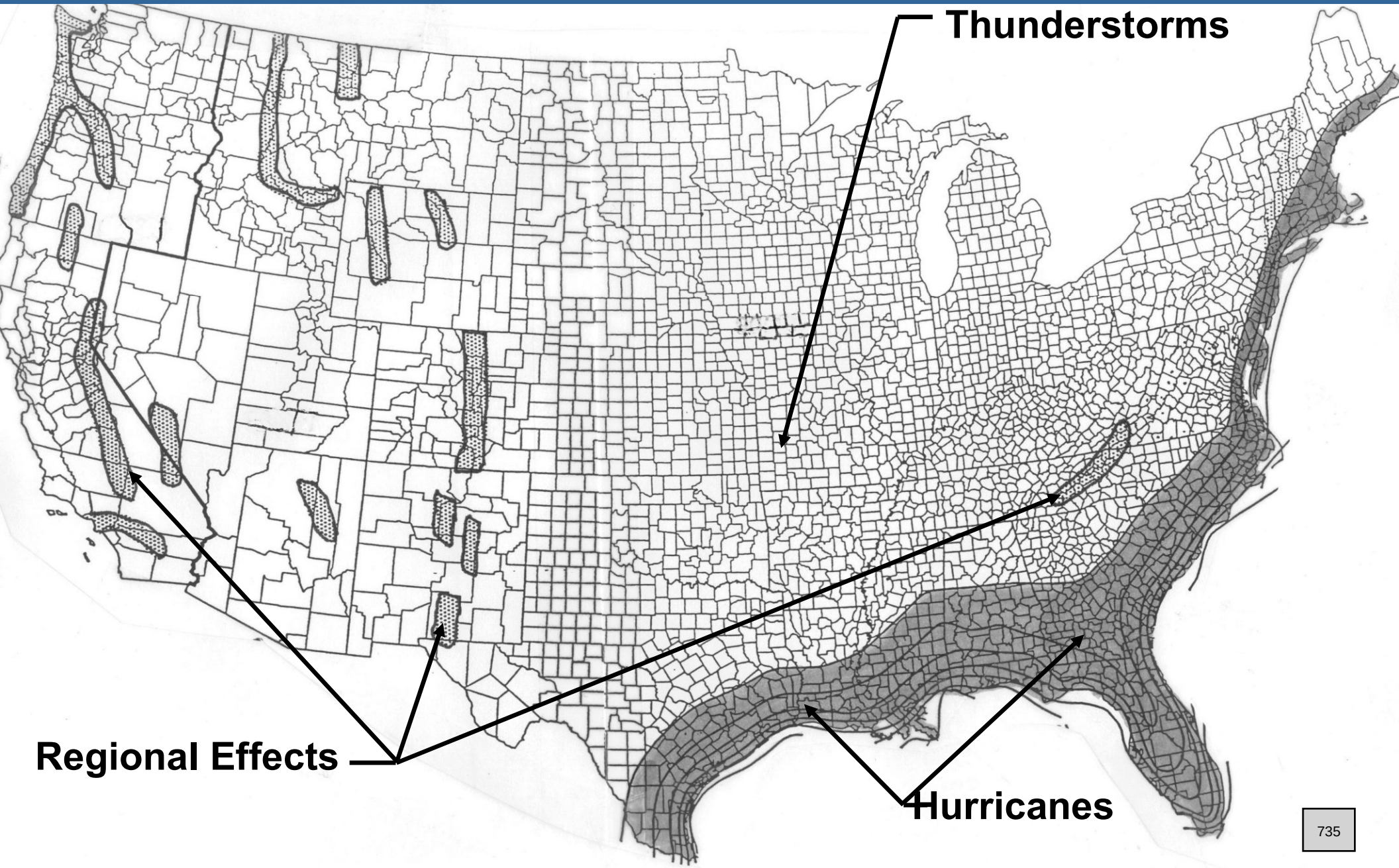
Hurricanes

- Size and duration makes much higher probability of striking a given coastal location.
- Control design wind speeds along:
  - Atlantic and Gulf coasts.
  - Islands of the Caribbean.
  - Islands of the Pacific.
- Return period greater than 50 years is used on the hurricane coast to provide consistent risk of failure.

Special Wind Regions

- Regional wind effects such as:
  - Wind blowing over mountain ranges
  - Wind blowing through gorges and valleys
- These increase the wind speeds above those shown on the map.
- Consultation with wind engineers or meteorologists may be required.

Controlling Factors - Wind Speed



Velocity Pressure

ASCE 7-98, ASCE 7-02, ASCE 7-05:

$$q = \left(0.00256V^2\right)K_z K_{zt} K_d I$$

Numerical Constant

The constant 0.00256 reflects the mass density of air for the standard atmosphere, i.e., the temperature of 59^0F and sea level pressure of 29.92 in. of mercury, and dimensions associated with wind speed in miles per hour.

Constant = ½ [(0.0765 lb/cu ft) / (32.2 ft/sec^2)]

x [(mi/h) (5280 ft/mi) x (1h/3600sec)]^2

= 0.00256

Basic Wind Speed

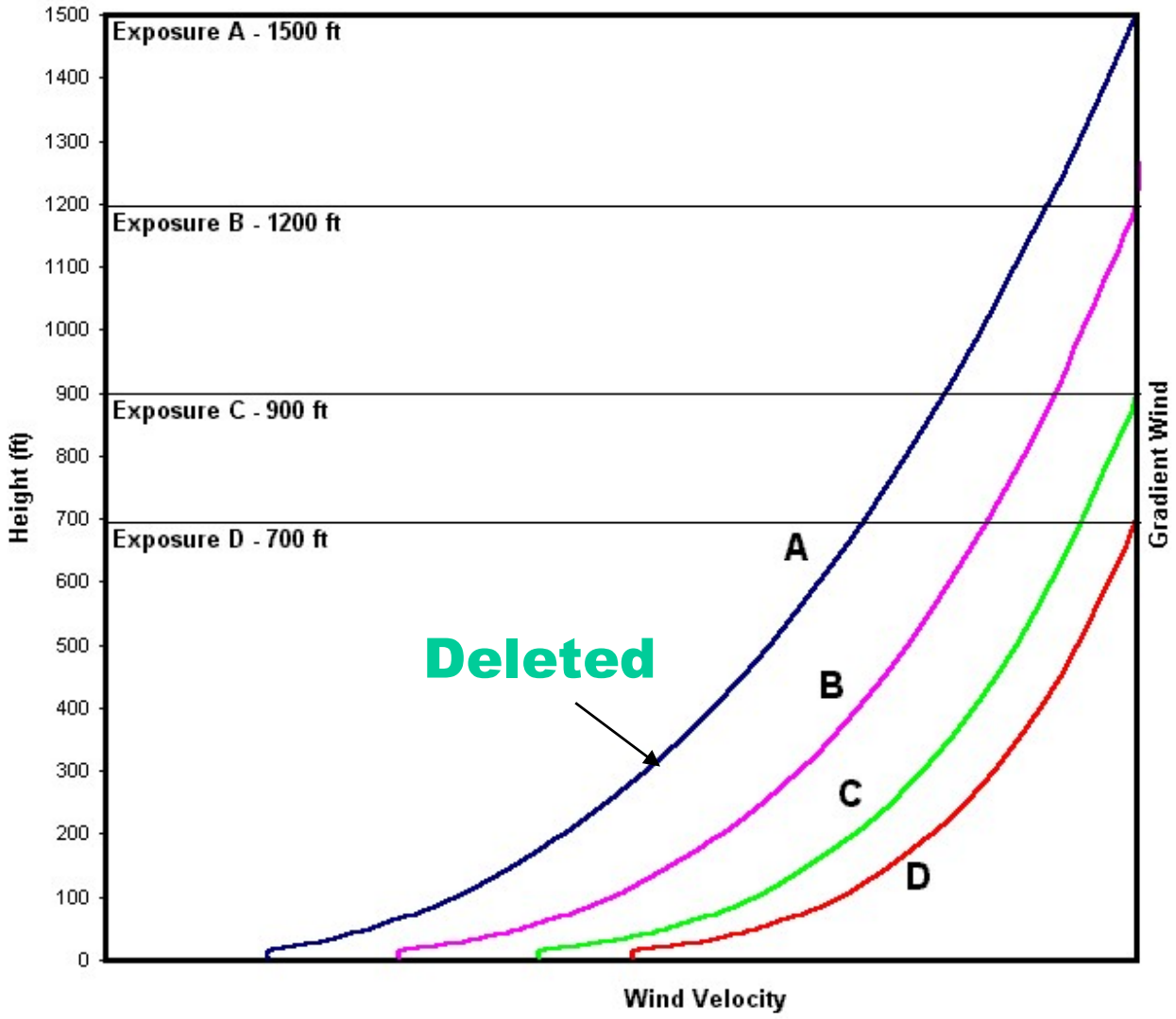
Basic wind speed, *V*: 3-second gust speed at 33 ft (10 m) above the ground in Exposure C and associated with an annual probability of 0.02 of being equaled or exceeded (50-year mean recurrence interval).

Velocity Pressure

ASCE 7-98, ASCE 7-02, ASCE 7-05:

$$q = \left(0.00256V^2\right)K_z K_{zt} K_d I$$

Wind Velocity Profiles & Boundary Layer Thickness



Exposure Constant

$$K_z = 2.01\left(z / z_g\right)^{2/\alpha}$$

Parabolic Equation of “Power Law” curves.

z is the height above ground.

z_g is the thickness of the boundary layer for each exposure category (B, C, D).

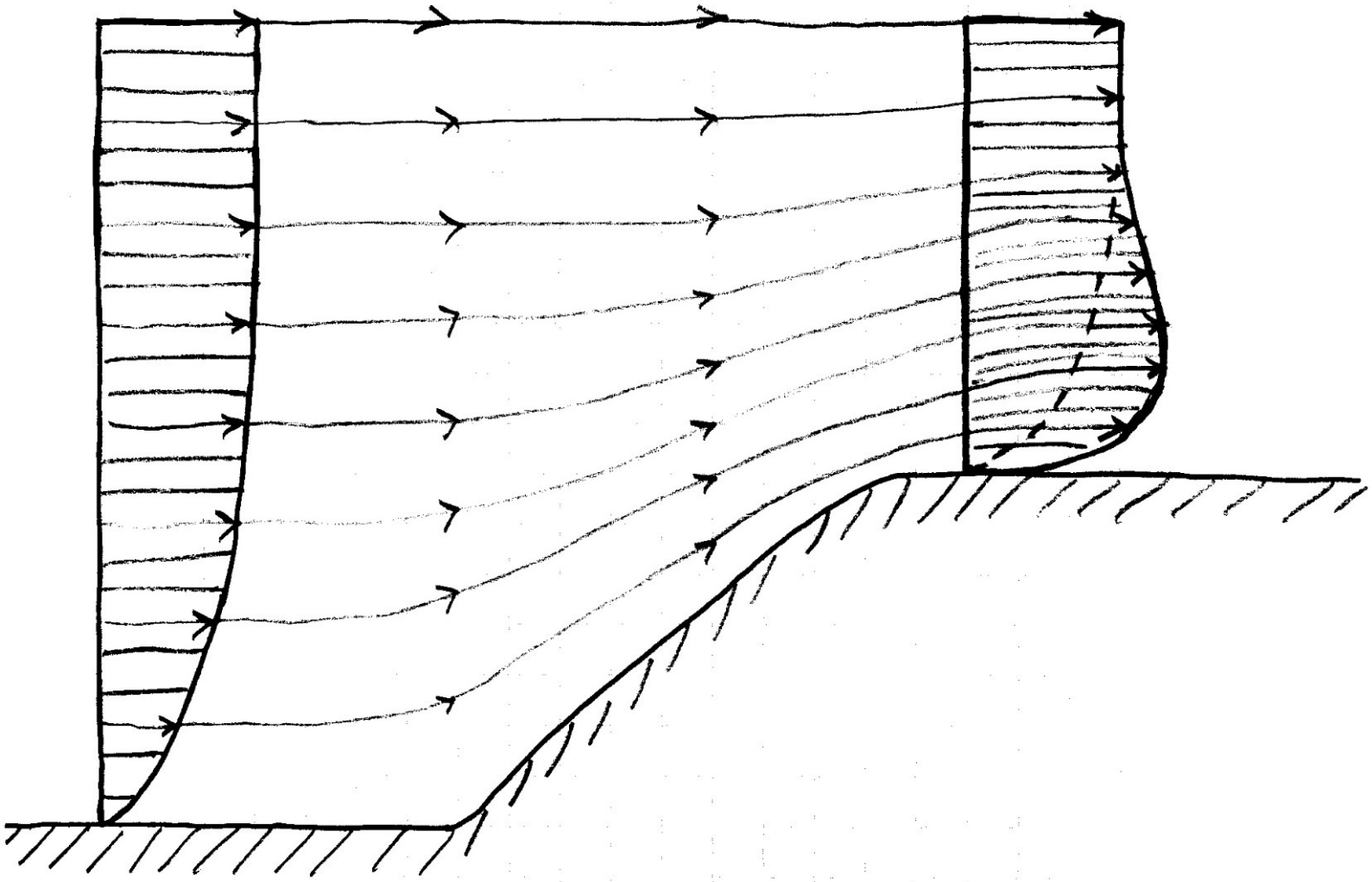
α is the power law exponent for each exposure category, equal to 7.0, 9.5, and 11.5 for Exposures B, C, and D, respectively.

Velocity Pressure

ASCE 7-98, ASCE 7-02, ASCE 7-05:

$$q = \left(0.00256V^2\right)K_z K_{zt} K_d I$$

Topographic Wind Speed-up Effect

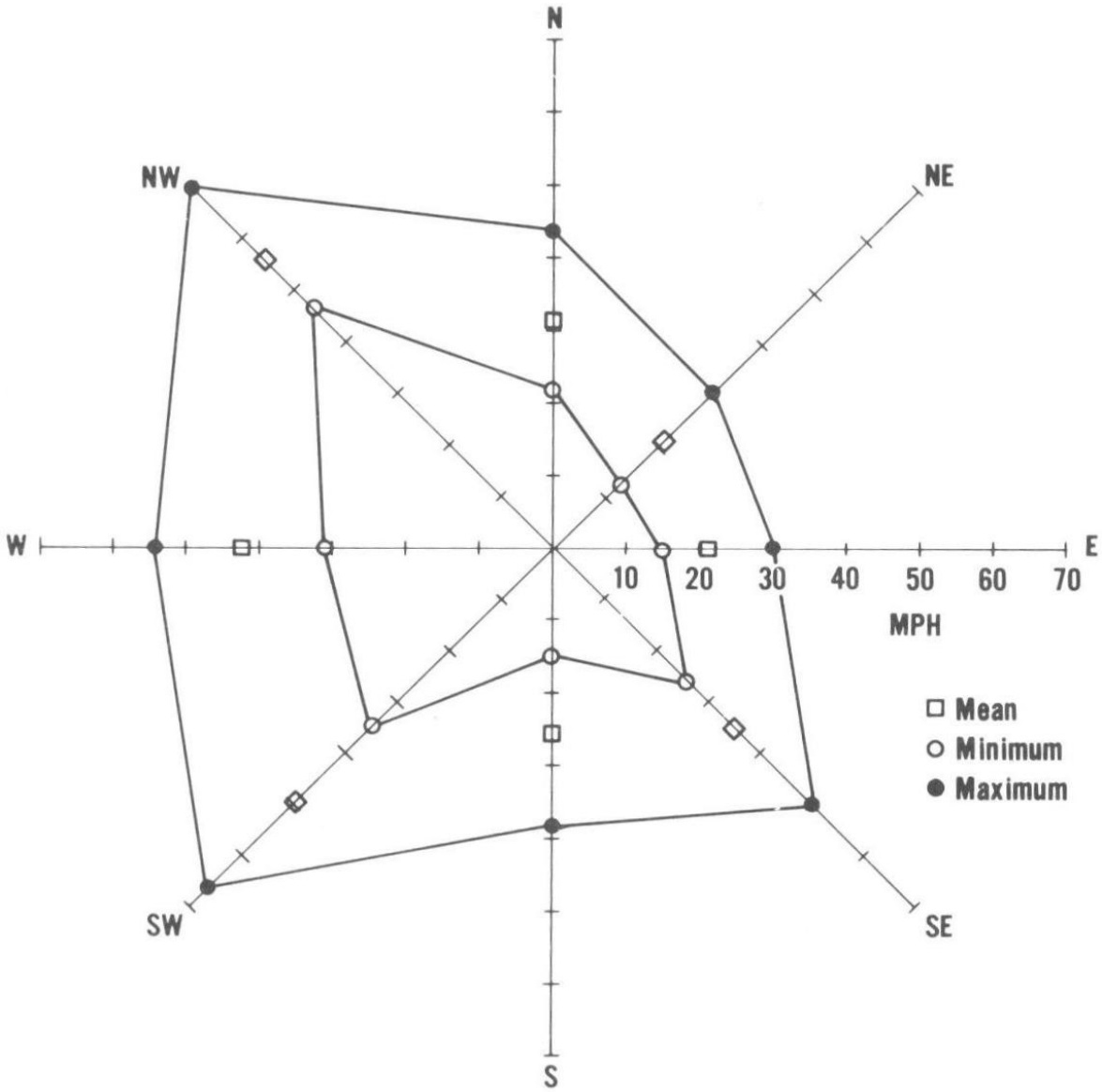


Velocity Pressure

ASCE 7-98, ASCE 7-02, ASCE 7-05:

$$q = \left(0.00256V^2\right)K_z K_{zt} K_d I$$

Directionality



Gust

$$p = q \times G \times C_p$$

- Rapid fluctuation of wind
- Ordinary structures sensitive to peak gusts of about 1 sec duration.
- Use of fastest-mile wind in design inadequate

  Gust speed, $V_g = G_v V$
- Pressure generated by gust, $p_g = G_p p$

  $p \propto V^2 \quad \therefore G_p = G_v^2$
- Flexible structures more sensitive to gust.

Gust Effect Factor

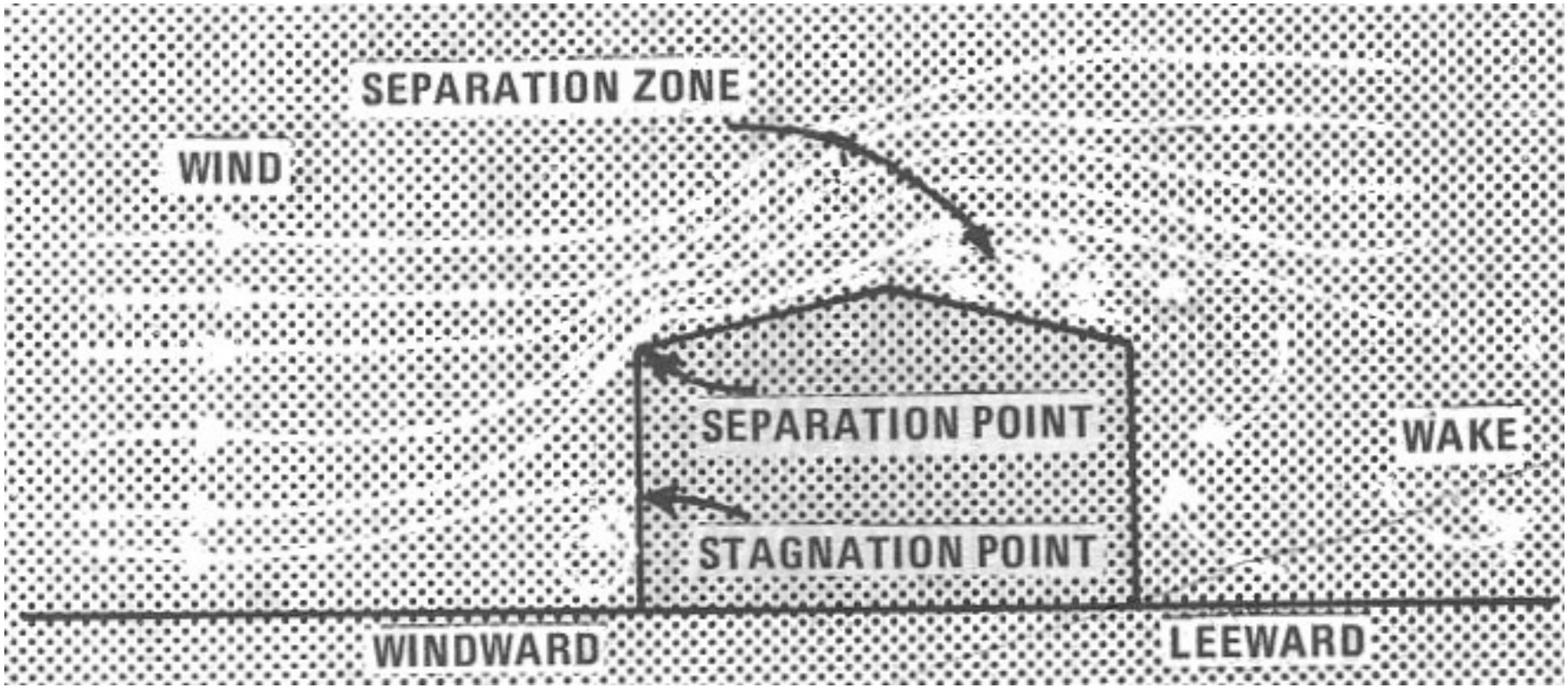
- Accounts for the loading effects in the along-wind direction (parallel to the direction of the wind) due to wind turbulence-structure interaction.
- Also accounts for along-wind loading effects due to dynamic amplification for flexible structures.
- Does not account for other dynamic effects such as across-wind loads.

Gust Effect Factor (*G*)

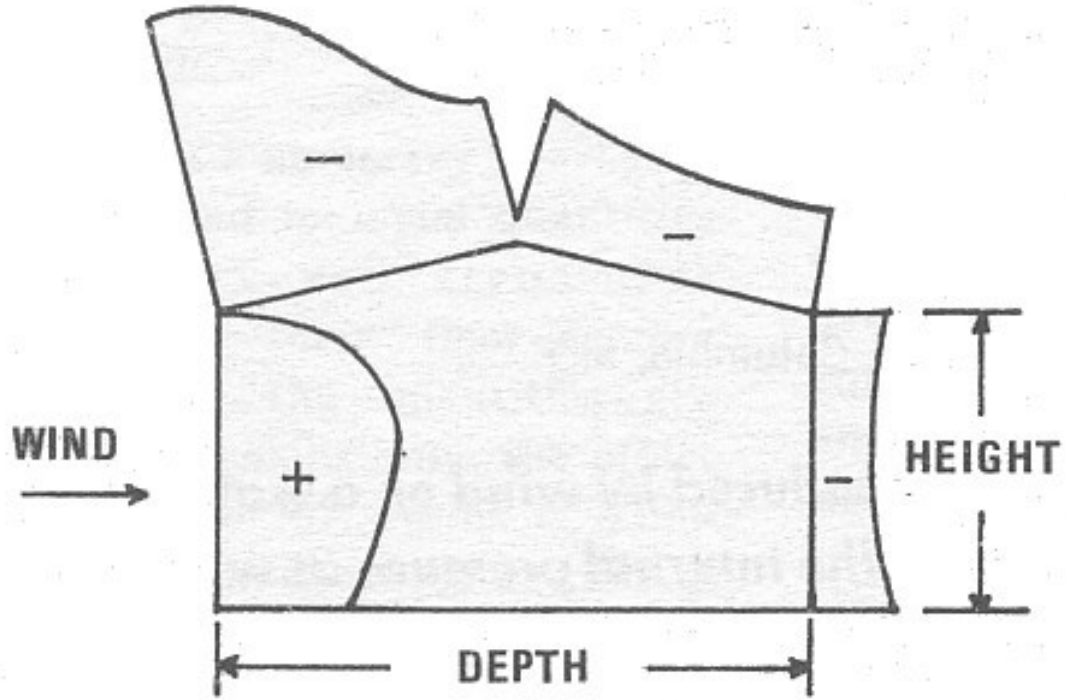
Starting with ASCE 7-95,

- *G* may be taken as 0.85 for all rigid buildings' MWFRS.
- *G* must be calculated for flexible buildings' MWFRS.
- *G* is included in a combined GC_p term for Low-Rise MWFRS and Components and Cladding.

Wind Flow Around Building



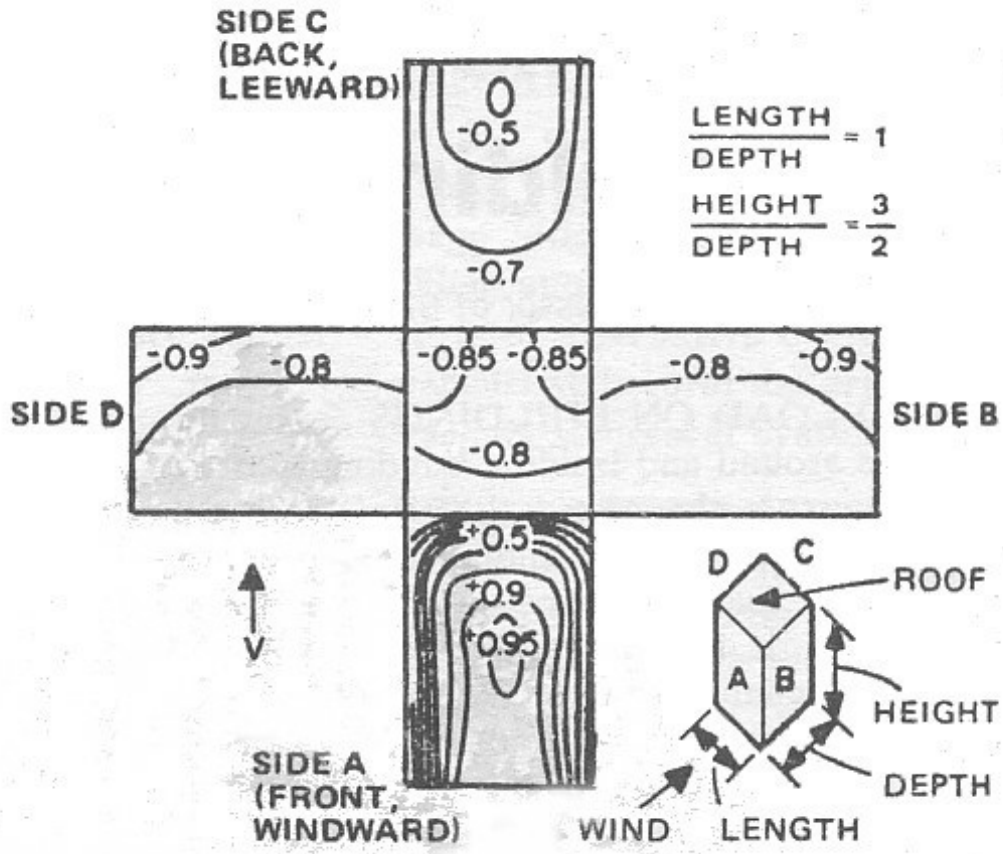
External Pressure due to Wind



Dimensionless Pressure or Pressure Coefficient

$$C_p = \frac{p - p_a}{(\frac{1}{2})\rho V^2} = \frac{p'}{(\frac{1}{2})\rho V^2}$$

p = actual pressure at any arbitrary point on building, psf

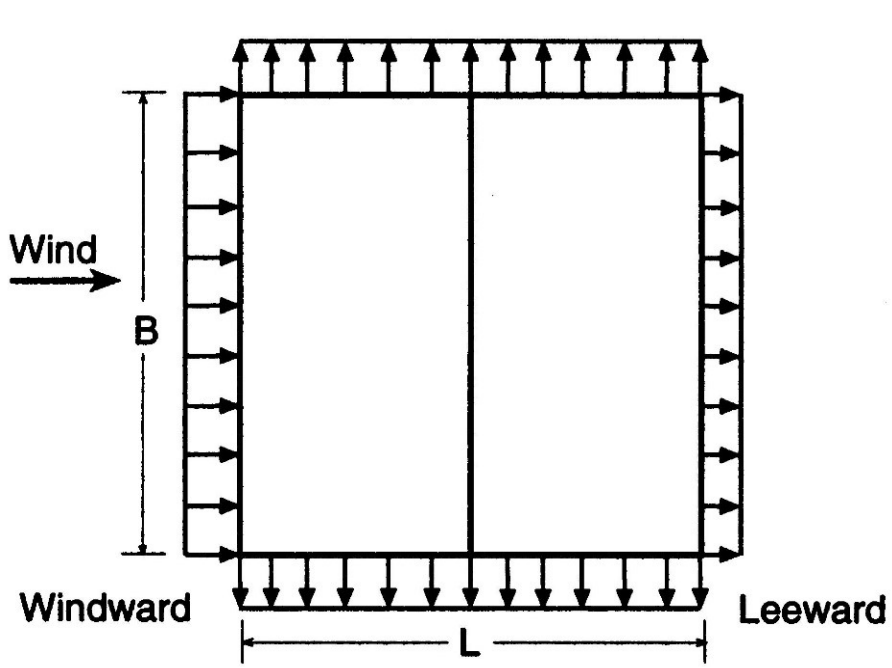


Pressure Coefficients (C_p)

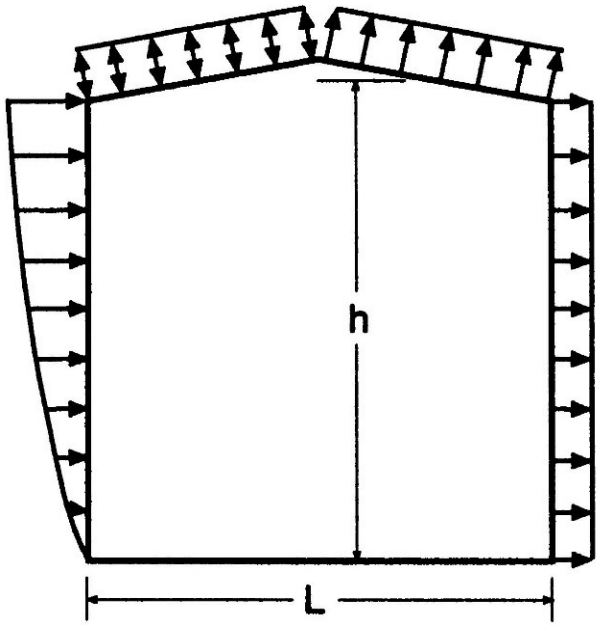
- C_p determined experimentally in wind tunnel.
- Values vary for different types of building shapes, and for the different methods used in the provisions.
- Consistently lower values for MWFRS coefficients compared to C&C.
- MWFRS correlated between the pressure values on the different surfaces.
- C&C uses worst case values.

Wind-resistant Design

Wind Pressures on a Building



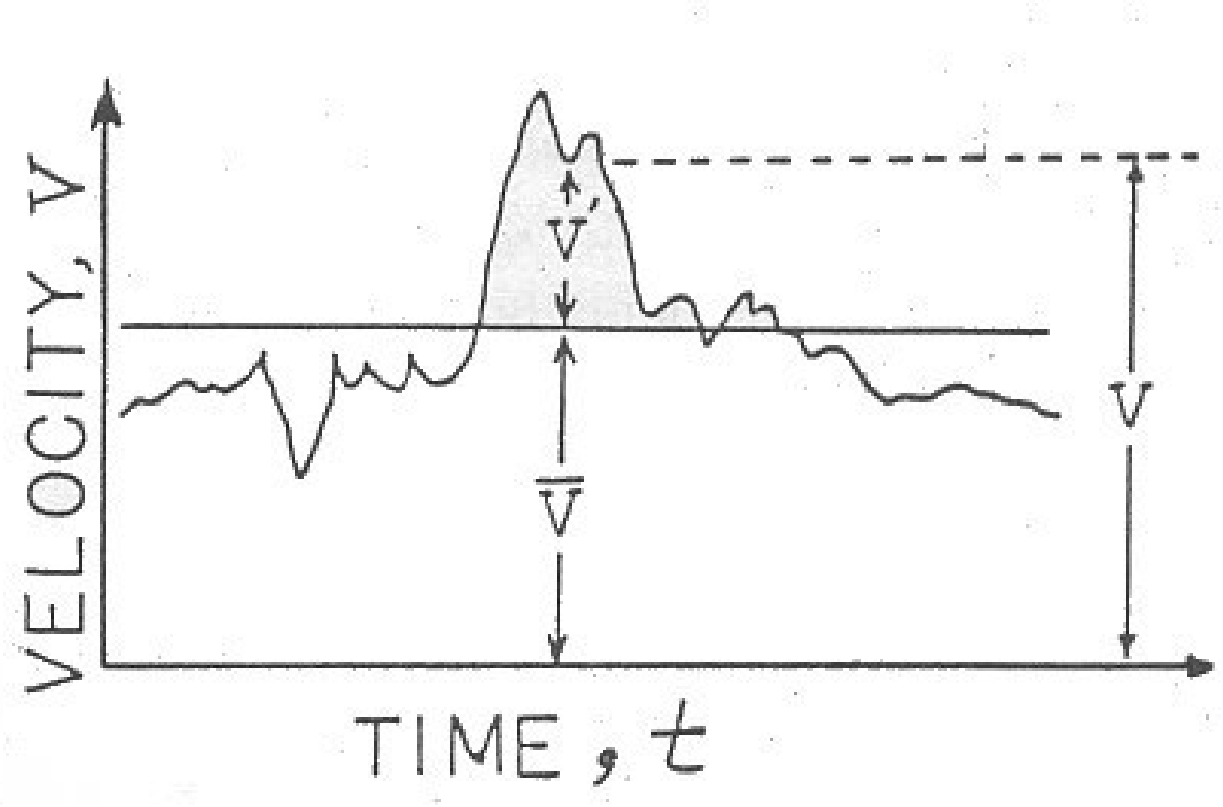
PLAN



ELEVATION

Wind Velocity

Instantaneous velocity of wind at a point as a function of time:



Fastest-Mile Wind

- Maximum wind speed averaged over one mile of wind passing through the anemometer.

- Averaging time of fastest-mile wind: T(sec) $3600/V_f$

  V_f – fastest-mile wind speed in mph

  For V_f = 60 mph – T = 3600/60 = 60 sec

  For V_f = 120 mph – T = 3600/120 = 30 sec

Return Period

- Also known as mean recurrence interval (MRI).
- In most U.S. inland locations, MRI of 50 years was used for normal-use structures.
- Return period greater than 50 years was used on the hurricane coast to provide consistent risk of failure.
- MRI for critical facilities such as hospitals was 100 years.
- MRI for low-risk buildings such as barns was 25 years.

Return Period

ANSI A58.1-72:

Mean Recurrence Interval. A basic wind speed with a 50-year MRI shall be used for all permanent structures except those that, in the judgment of the engineer or the authority having jurisdiction, present a high degree of sensitivity to wind and an unusually high degree of hazard to life and property in case of failure. In the latter case, a 100-year mean recurrence interval shall be used. For structures that have no human occupants or where there is negligible risk to human life, a 25-year MRI may be used.

Return Period

ANSI A58.1-72:

A 50-year MRI design wind speed map and a separate 100-year MRI design wind speed map were provided

A 25-year MRI wind speed map was provided in Appendix (Commentary)

Unusual Exposures

ANSI A58.1-72:

… For ocean promontories, mountains, gorges, and other unusual exposures, where wind records or experience indicates that the wind speeds given … are inadequate, higher basic wind speeds may be prescribed by the building official. All mountainous and hilly exposures must be carefully examined for such unusual conditions.

Basically the same language continued in ANSI A58.1-82.

Return Period

ANSI A58.1-82:

Only a 50-year MRI design wind speed map was provided.

Table in Appendix (Commentary) provided 25-year, 50-year, and 100-year MRI wind speed values for locations in the United States.

The table was continued in ASCE 7-88 and ASCE 7-93 despite introduction of Importance Factors

Importance Factor

- For MRI of 25, 50 , and 100 years -

  3 Maps???? - No!

- MRI was adjusted by using an importance factor, *I*.

- Ratio of difference in velocity pressure from one MRI to another is a fairly consistent ratio for non-hurricane locations.

Importance Factor, *I*, (Wind Loads)

ASCE 7-88 and ASCE 7-93:

Building Classification	Importance Factor, *I*	
	100 miles from hurricane oceanline and in other areas	At hurricane oceanline
I (Standard Occupancy)	1.00 (50-year MRI)	1.05
II (Assembly Buildings	1.07 (100-year MRI)	1.11
III (Essential Facilities)	1.07 (100-year MRI)	1.11
IV (Low-Risk)	0.95 (25-year MRI)	1.00

Factor applied to wind velocity, not pressure

Importance Factor, *I*, (Wind Loads)

ASCE 7-95:

Building Classification	Importance Factor, *I*
	100 miles from hurricane oceanline and in other areas
I (Low-Risk)	0.87 (25-year MRI)
II (Standard Occupancy)	1.00 (50-year MRI)
III (Assembly Buildings	1.00 (50-year MRI)
IV (Essential Facilities)	1.15 (100-year MRI)

Factor applied to wind pressure, not velocity

Importance Factor

ASCE 7-98, ASCE 7-02, ASCE 7-05:

Occupancy Category	Importance Factor (Non-Hurricane Prone Regions with *V* = 85-100 mph and Alaska)	Importance Factor (Hurricane Prone Regions with *V* > 100 mph)
I	0.87	0.77
II	1.00	1.00
III and IV	1.15	1.15

Factor applied to wind pressure, not velocity

ASCE 7 Wind

ANSI A58.1-72, ANSI A 58.1-82,

ASCE 7-88, ASCE 7-93:

Fastest-Mile Wind Speed, *V*

50-year MRI for standard occupancy structures

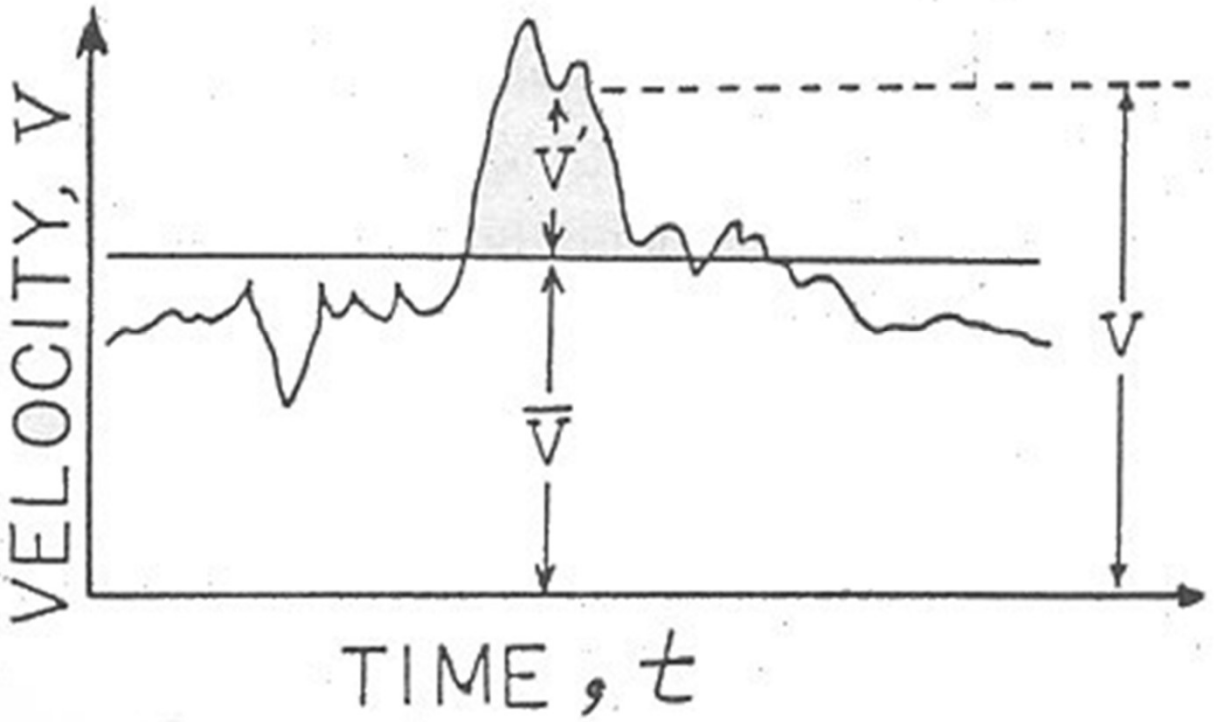
Wind speed contours for the entire country

Basic wind speed in most of the country: 70 mph

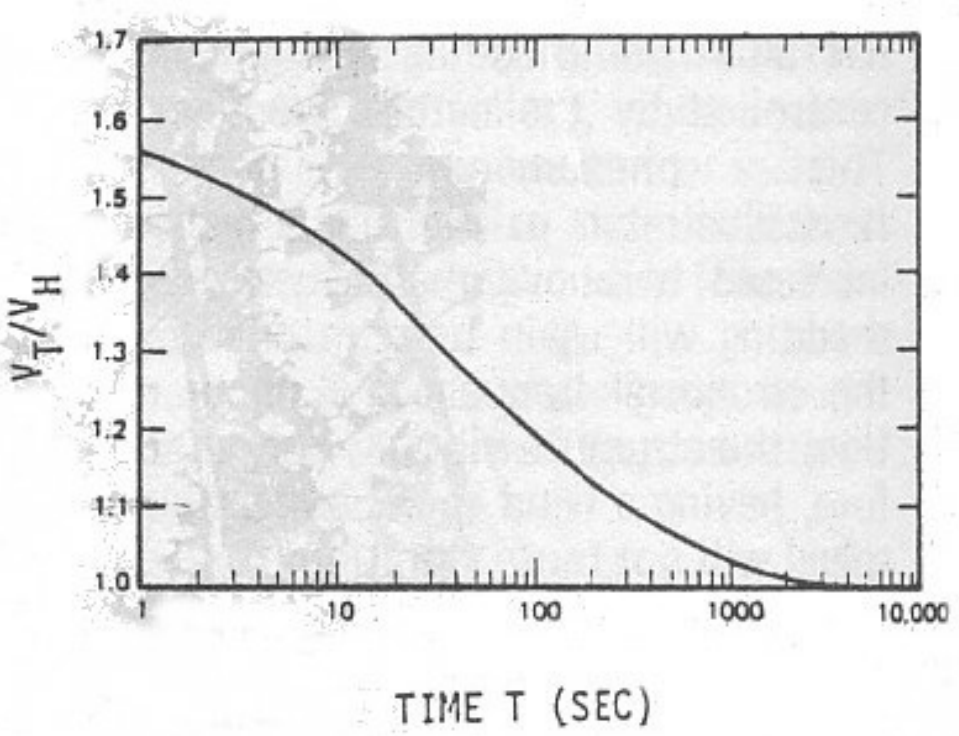
3-second Gust Speed

ASCE 7-95, ASCE 7-98, ASCE 7-02, ASCE 7-05:

50-year MRI 3-sec gust wind speed



3-second Gust Speed



- V_T = max. wind speed based on averaging time of T sec
- V_H = max. wind speed based on averaging time of 1 hour

3-second Gust Speed

ASCE 7-95, ASCE 7-98, ASCE 7-02, ASCE 7-05:

Basic wind speed

85 mph in California, Oregon, Washington

90 mph in rest of the country outside of hurricane-prone regions

Higher in hurricane-prone regions

“Service-Level” Wind

ASCE 7-05:

Load factor on *W* =1.6 in Strength Design

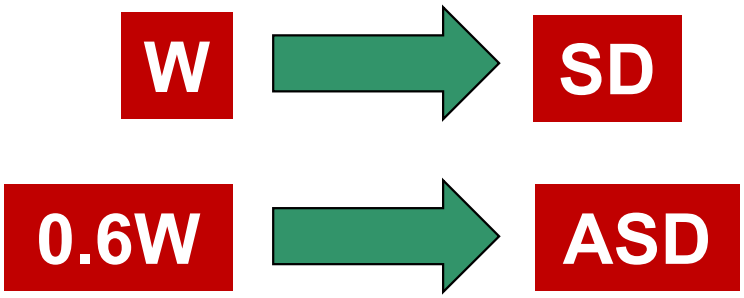
Load factor on *W* =1.0 in ASD.

“Strength-Level” Wind

ASCE 7-10:

Load factor on *W* changed to1.0 for Strength Design and 1/1.6 or 0.6 for ASD.

Thus, the design wind speed maps in ASCE 7-10 produce strength-level design wind forces. The mapped design wind speeds are, therefore, higher than in ASCE 7-05.



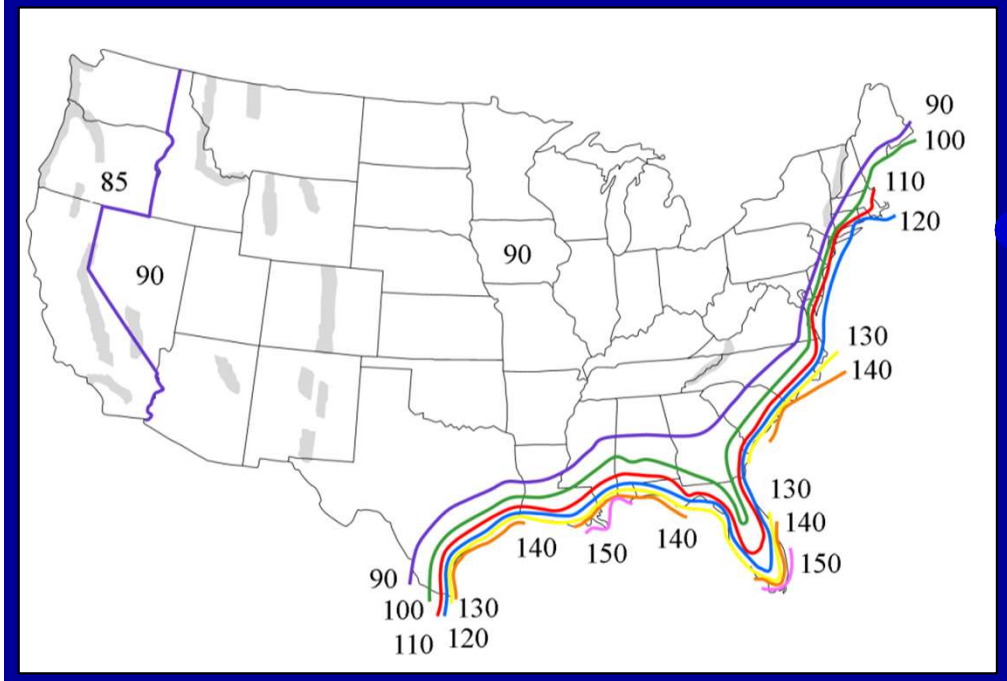
ASCE 7-10 Wind

No Importance Factor is used in wind design any more.

Basic Wind Speeds: 3 Maps replace need for Importance Factor

ASCE 7-10 Wind Speed Maps

ASCE 7-05 Chapter 6

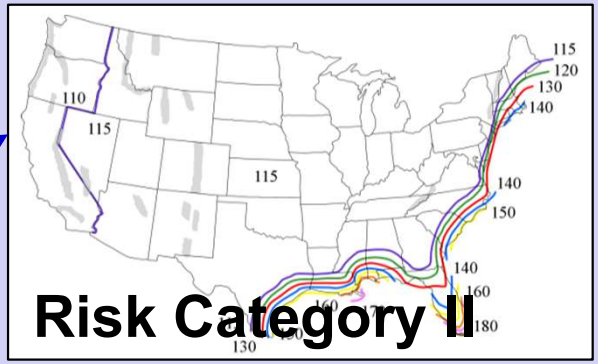


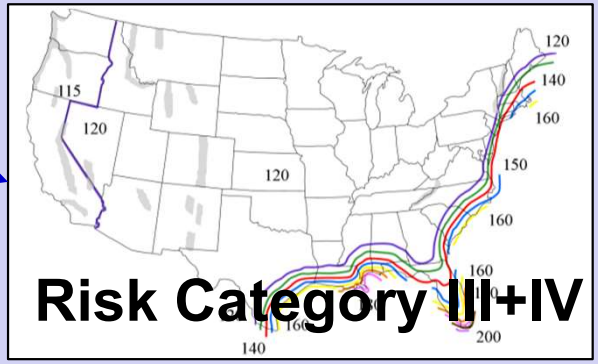
$\times\sqrt{1.6}$

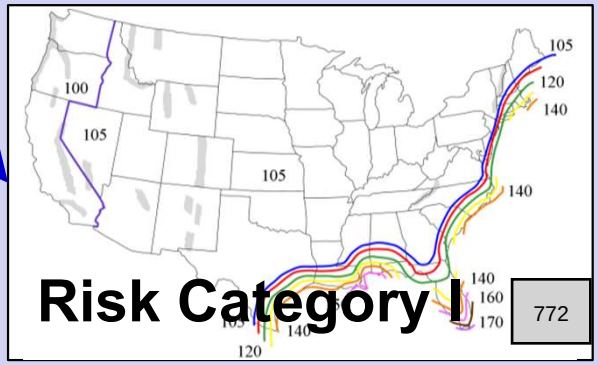
$\times\sqrt{1.6\times1.1}$

$\times\sqrt{1.6\times0.87}$

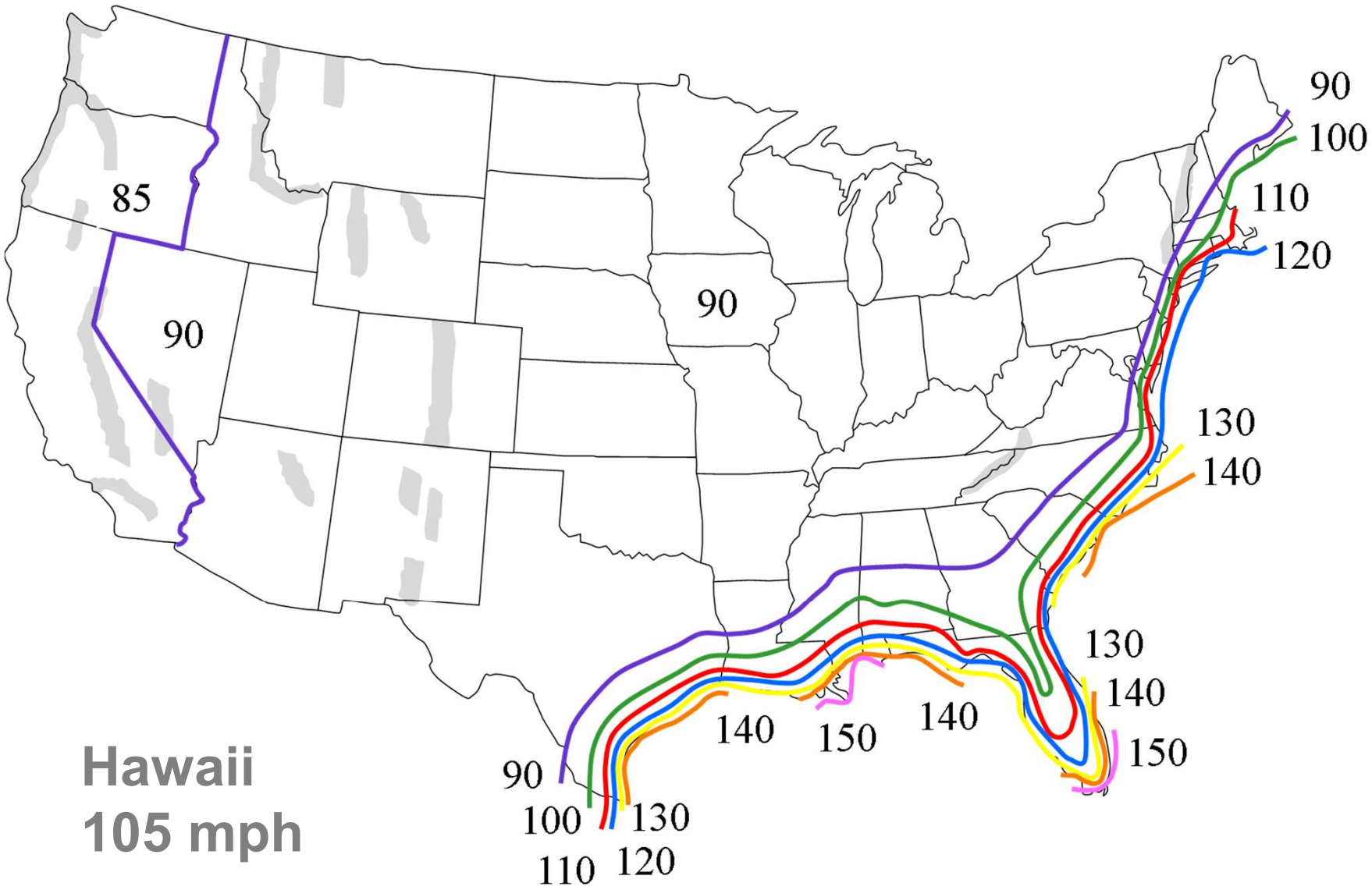
ASCE 7-10 Chapter 26





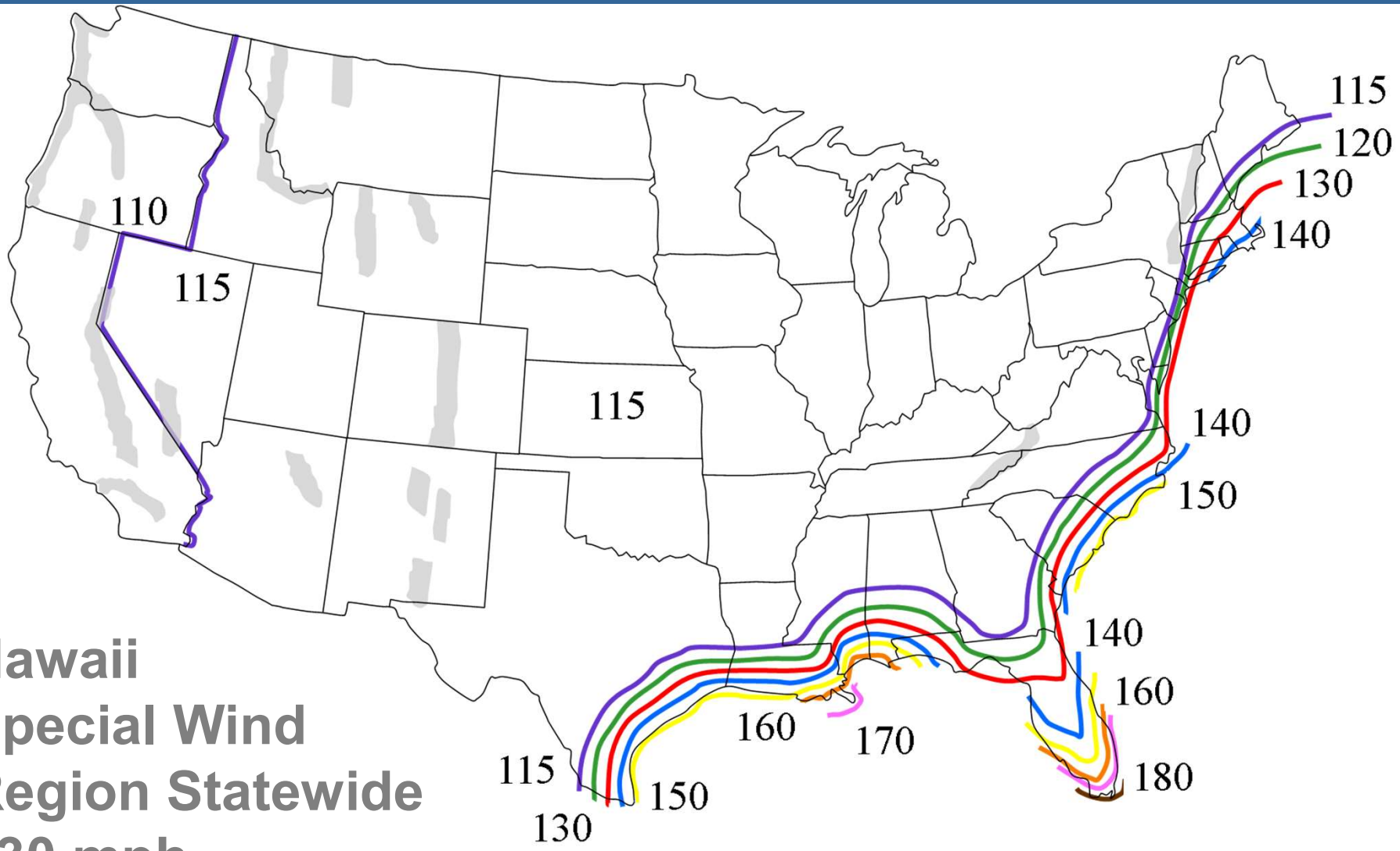


ASCE 7-05 Figure 6-1



Hawaii
105 mph

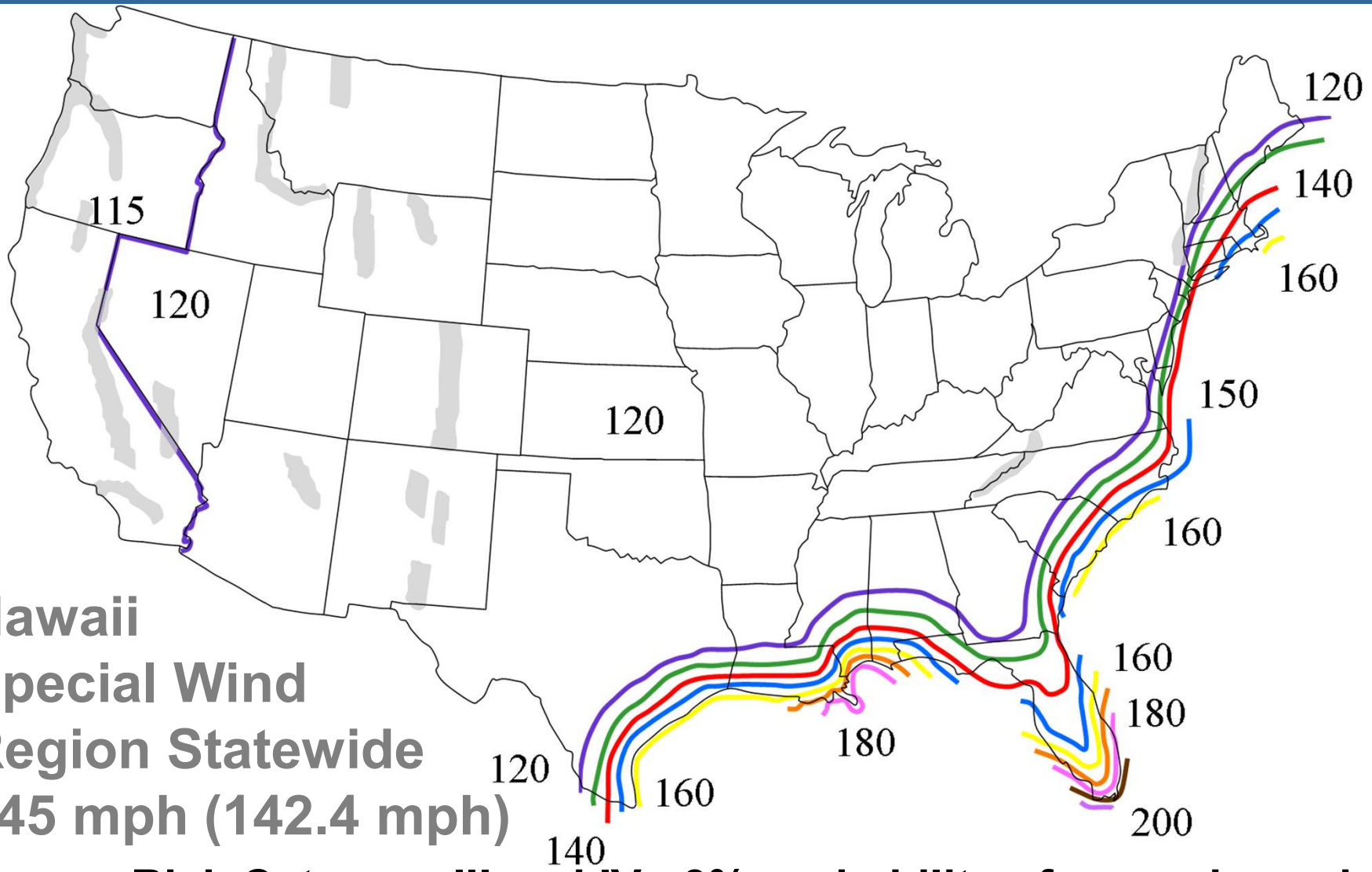
ASCE 7-10 Figure 26.5-1A



Hawaii
Special Wind
Region Statewide
130 mph
(132.8 mph)

Risk Category II - 7% probability of exceedance in 50 years, MRI of 700 years

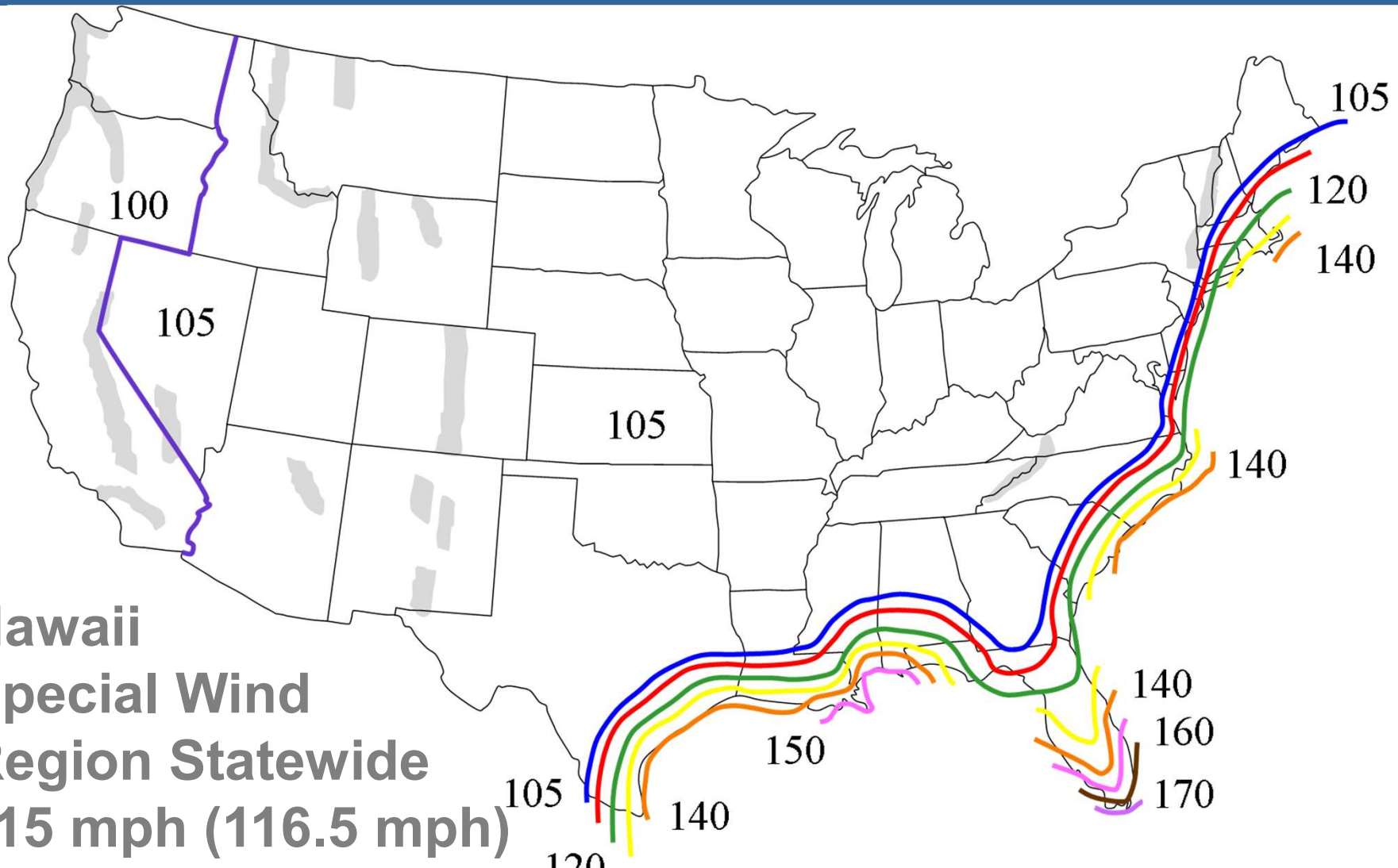
ASCE 7-10: Figure 26.5-1B



Hawaii
Special Wind Region Statewide
145 mph (142.4 mph)

Risk Category III and IV - 3% probability of exceedance in 50 years, MRI of 1700 years

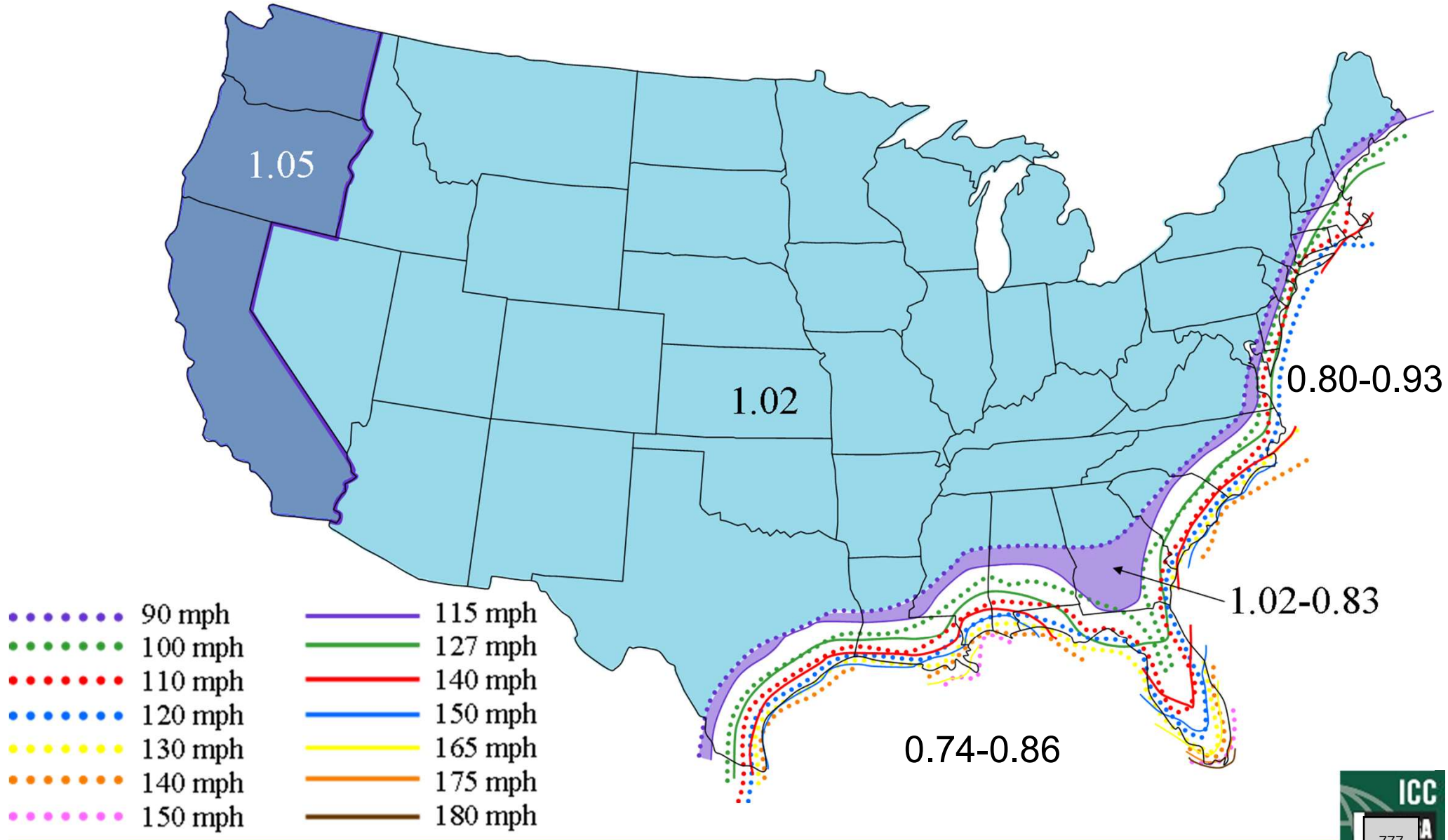
ASCE 7-10: Figure 26.5-1C



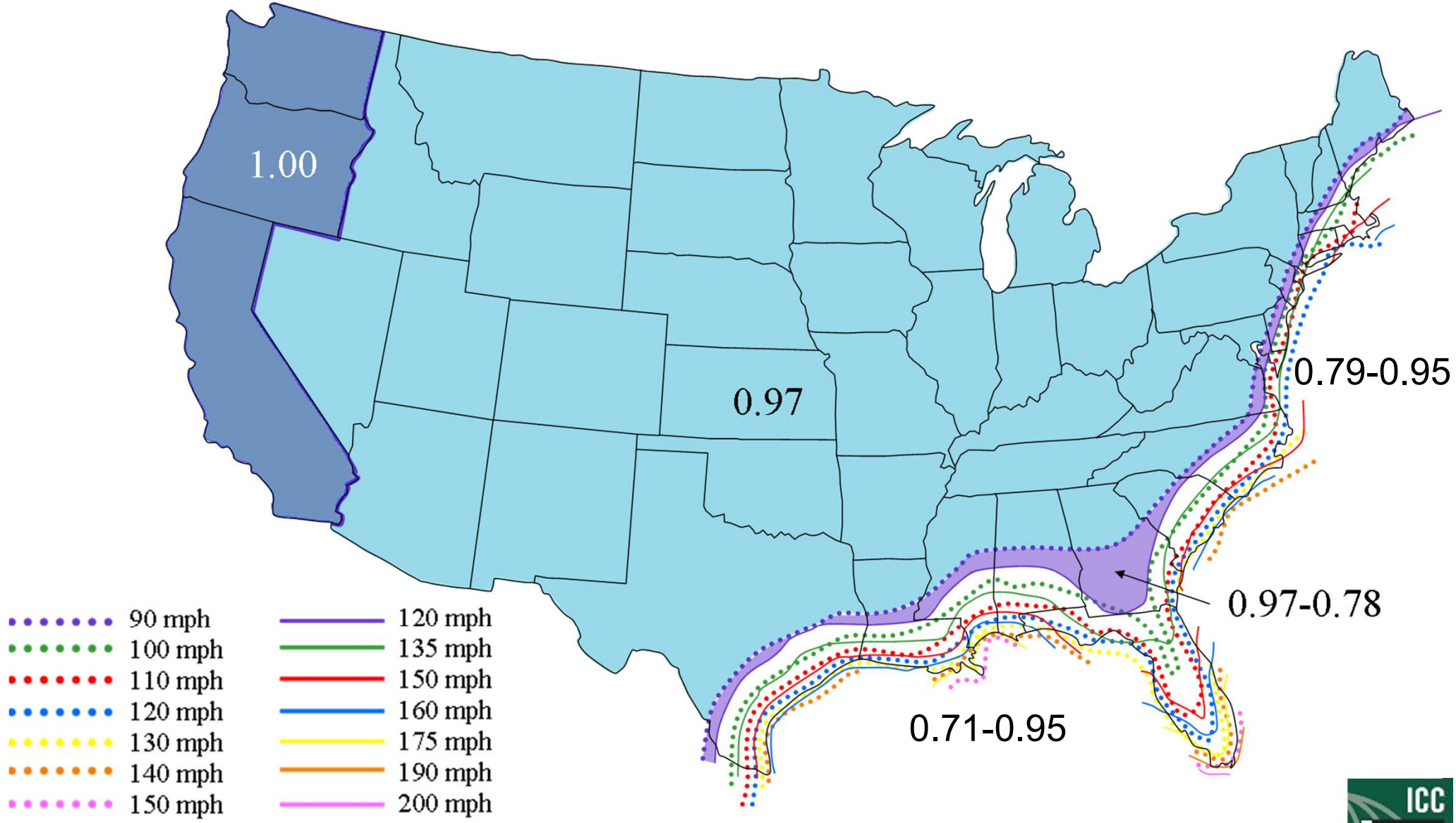
Hawaii
Special Wind Region Statewide
115 mph (116.5 mph)

Risk Category I - 15% probability of exceedance in 50 years, MRI of 300 years

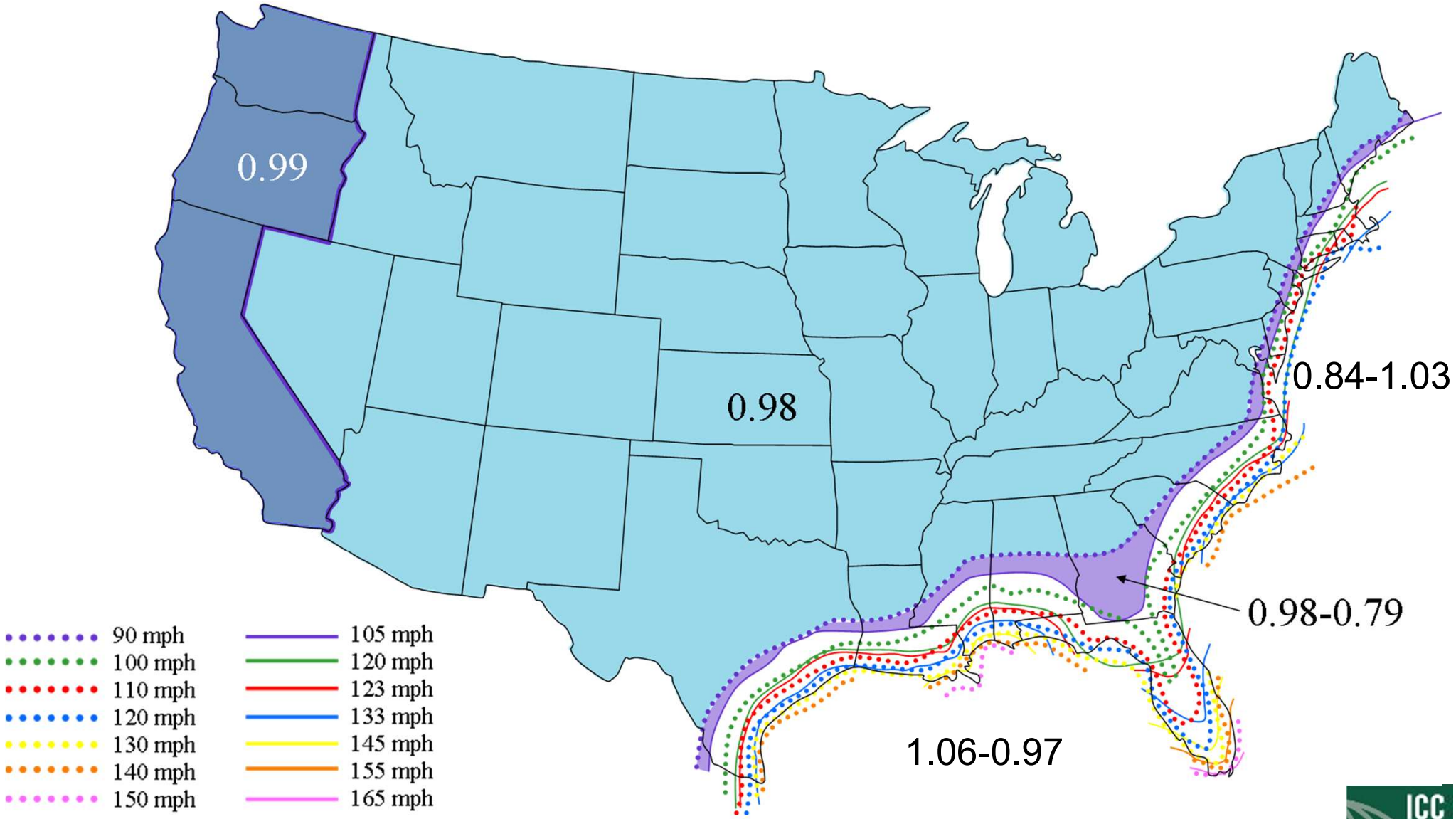
Risk Category II Comparison



RC III and IV Comparison



Risk Category I Comparison



Equations for Velocity Pressure

ANSI A58.1-1972: $q_{30} = 0.00256 V_{30}^2$

ANSI A58.1-1982, ASCE 7-88, ASCE 7-93:

$$q_z = 0.00256 \boldsymbol{K_z} (\boldsymbol{I} V)^2$$

ASCE 7-95: $q_z = 0.00256 K_z \boldsymbol{K_{zt}} V^2 I$

ASCE 7-98, ASCE 7-02, ASCE 7-05:

$$q_z = 0.00256 K_z K_{zt} \boldsymbol{K_d} V^2 I$$

ASCE 7-10: $q_z = 0.00256 K_z K_{zt} K_d V^2$

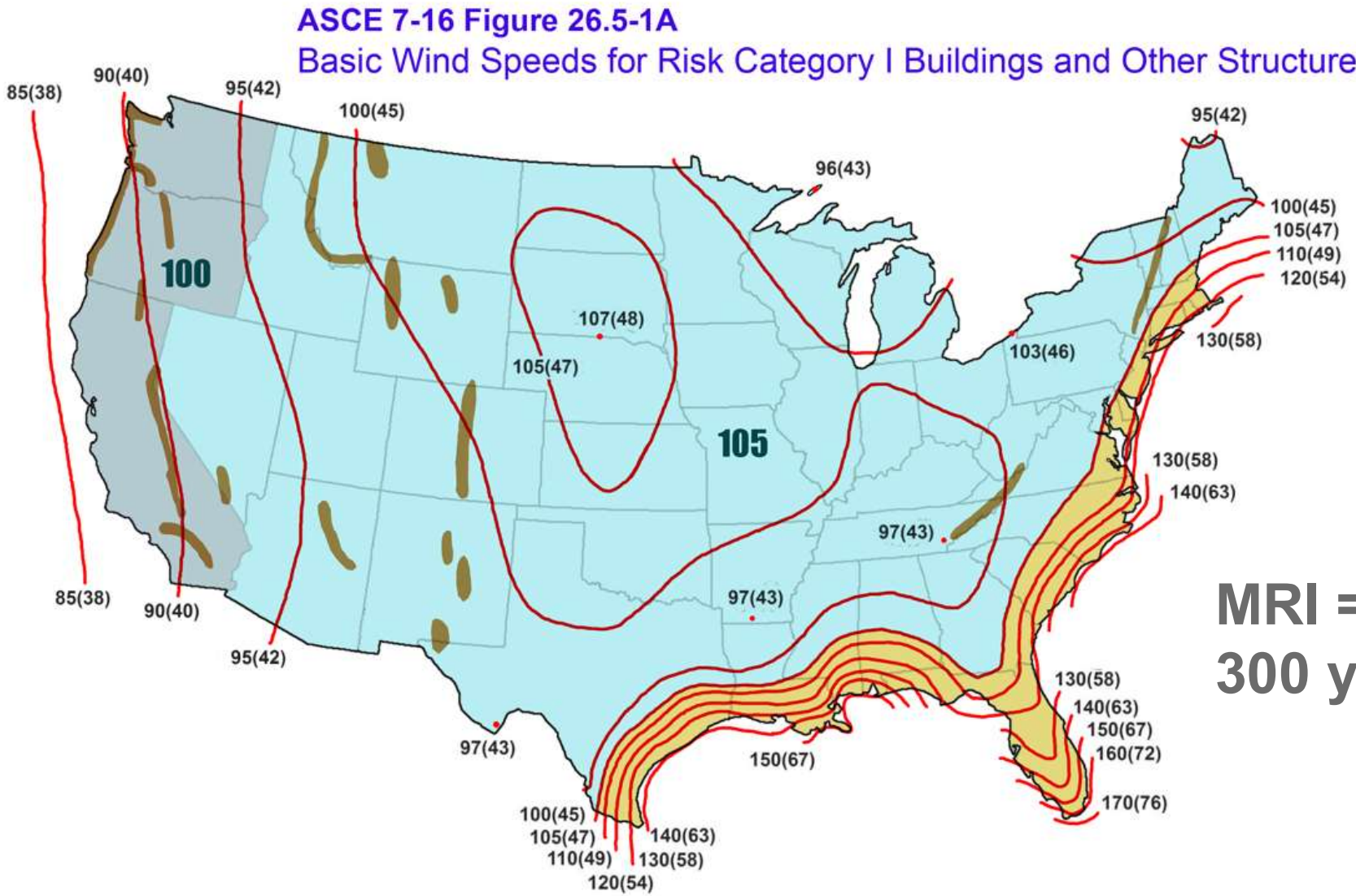
ASCE 7-16: $q_z = 0.00256 K_z K_{zt} K_d \boldsymbol{K_e} V^2$

ASCE 7-16 Design Wind Speed Maps

ASCE 7-16:

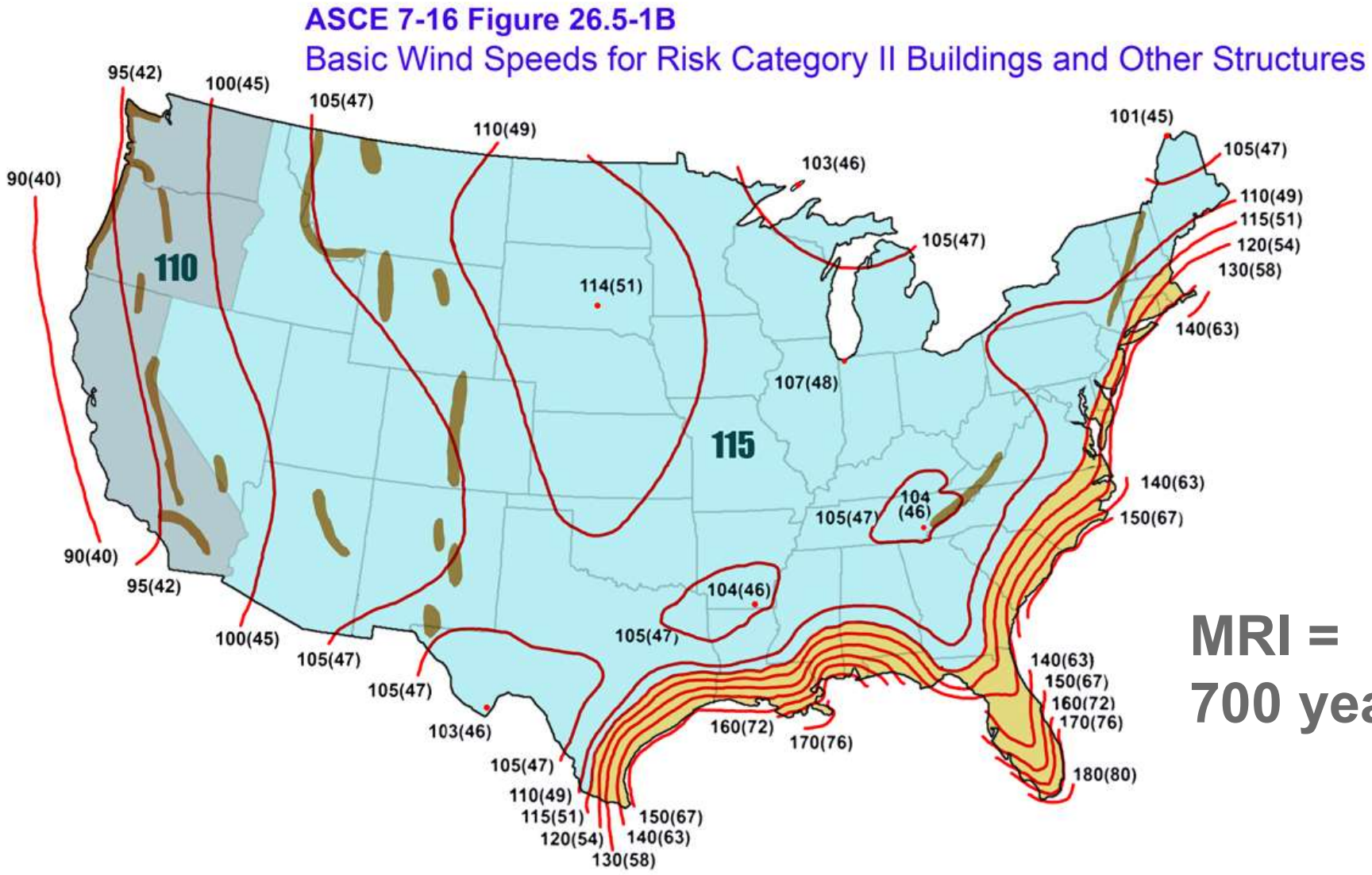
- Basic Wind Speed Maps, Figures 26.5-1 A, B, C Replaced
- New Figure D Introduced

ASCE 7-16 Design Wind Speed Map RC I



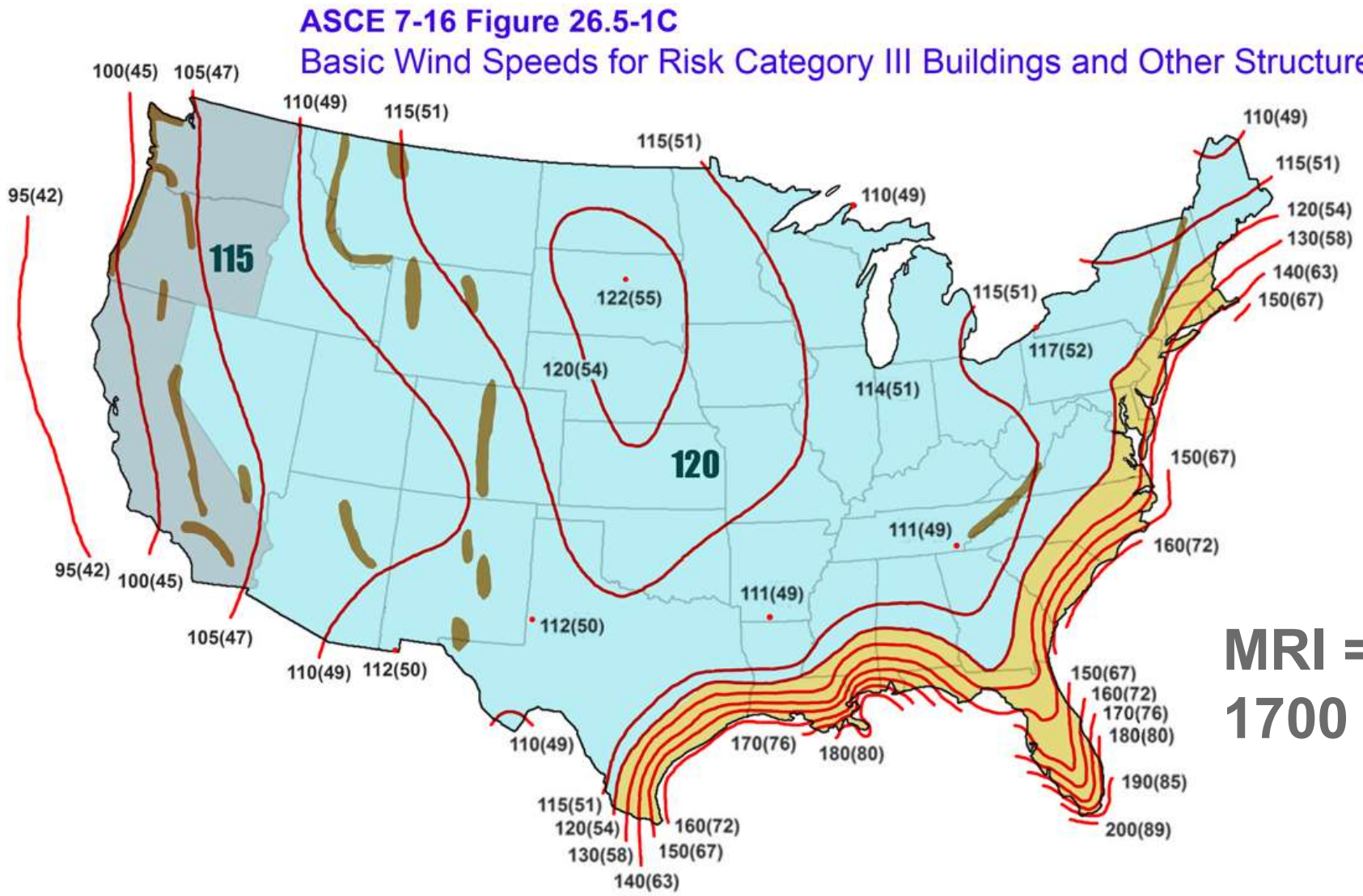
MRI = 300 years

ASCE 7-16 Design Wind Speed Map RC II



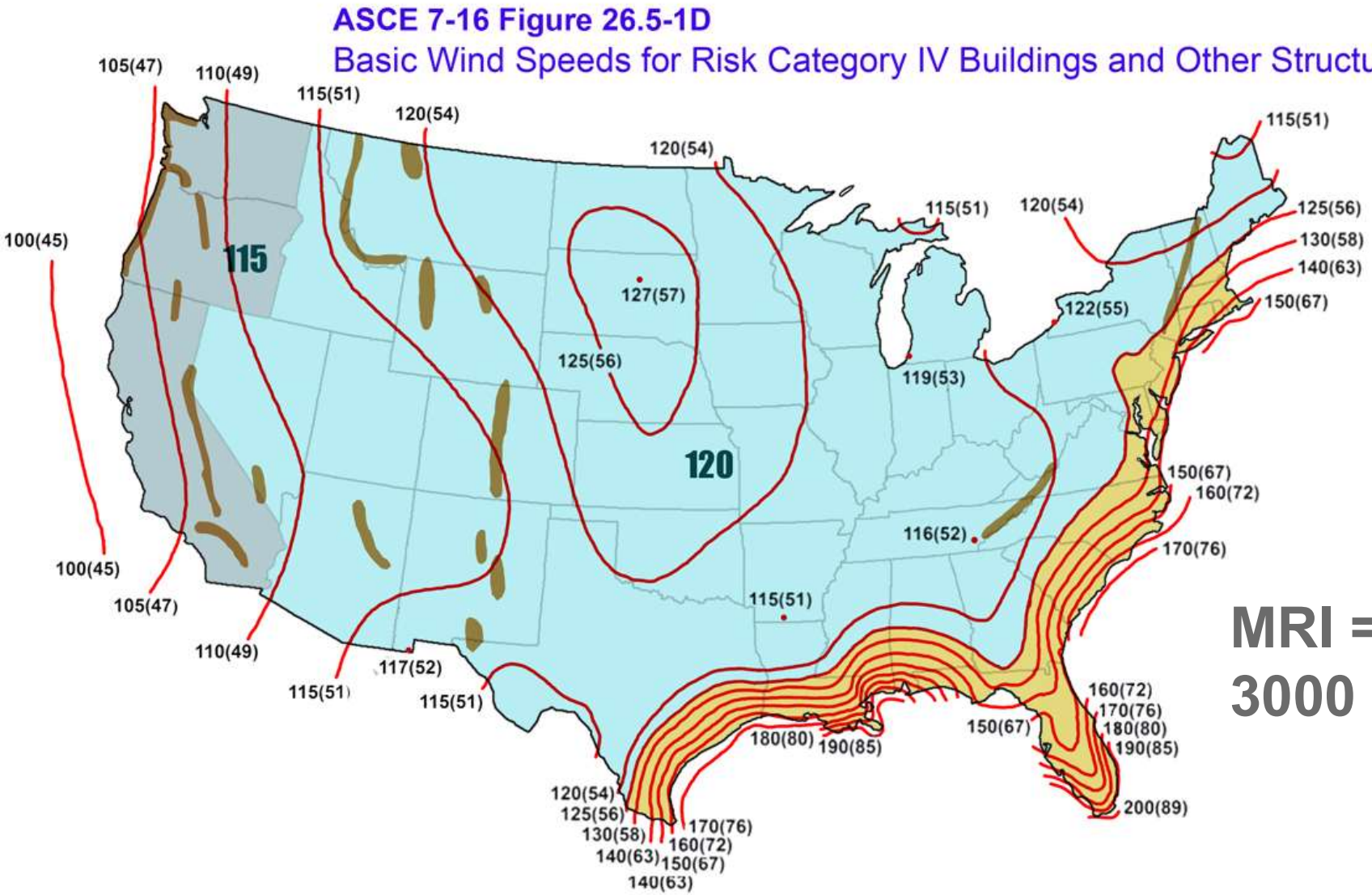
MRI = 700 years

ASCE 7-16 Design Wind Speed Map RC III



MRI = 1700 years

ASCE 7-16 Design Wind Speed Map RC IV



MRI = 3000 years

26 Effective Wind Speed Maps for Hawaii

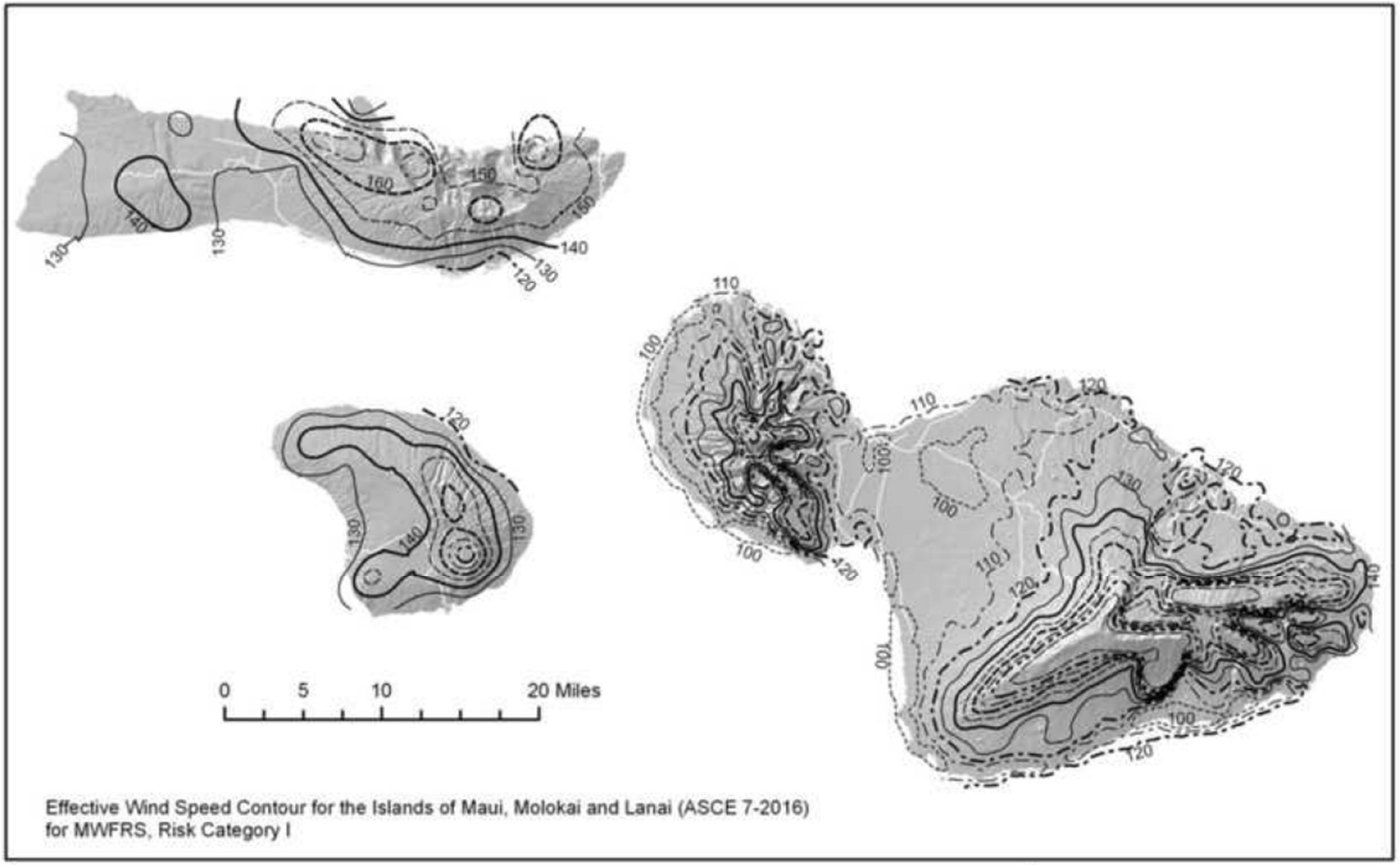
In the 2016 edition, microzoned “effective” wind speed maps for Hawaii were added in accordance with the strength design return periods including the effect of topography. The Hawaii Effective Wind Speeds are algebraically formulated to include the macroscale and mesoscale terrain-normalized values of K_{zt} and K_d (Chock et al 2005), i.e., $V_{effective}$ is the Basic Windspeed V multiplied by $\sqrt{(K_{zt} \times K_d/0.85)}$, so that the engineer is permitted to more conveniently use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.

26 Effective Wind Speed Maps for Hawaii

Note that local site conditions of finer toposcale, such as ocean promontories and local escarpments, should still be examined. Spatial resolution scales for digital modeling, including terrain effects, are as follows:

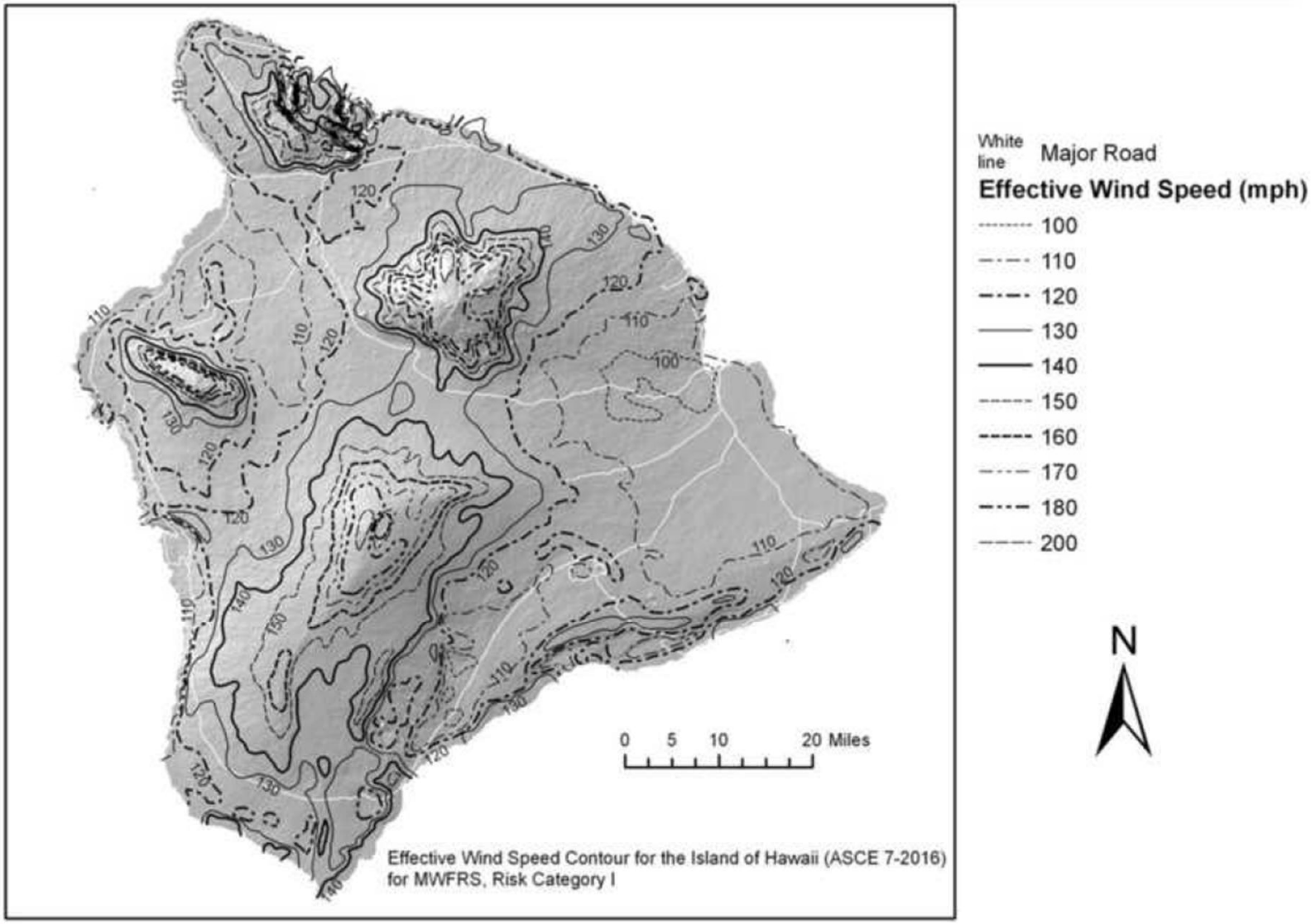
Scale	Spatial Resolution
Toposcale	10–200 m
Mesoscale	200 m–5 km
Macroscale	5–500 km

Effective Wind Speed Maps for Maui, Molokai, and Lanai

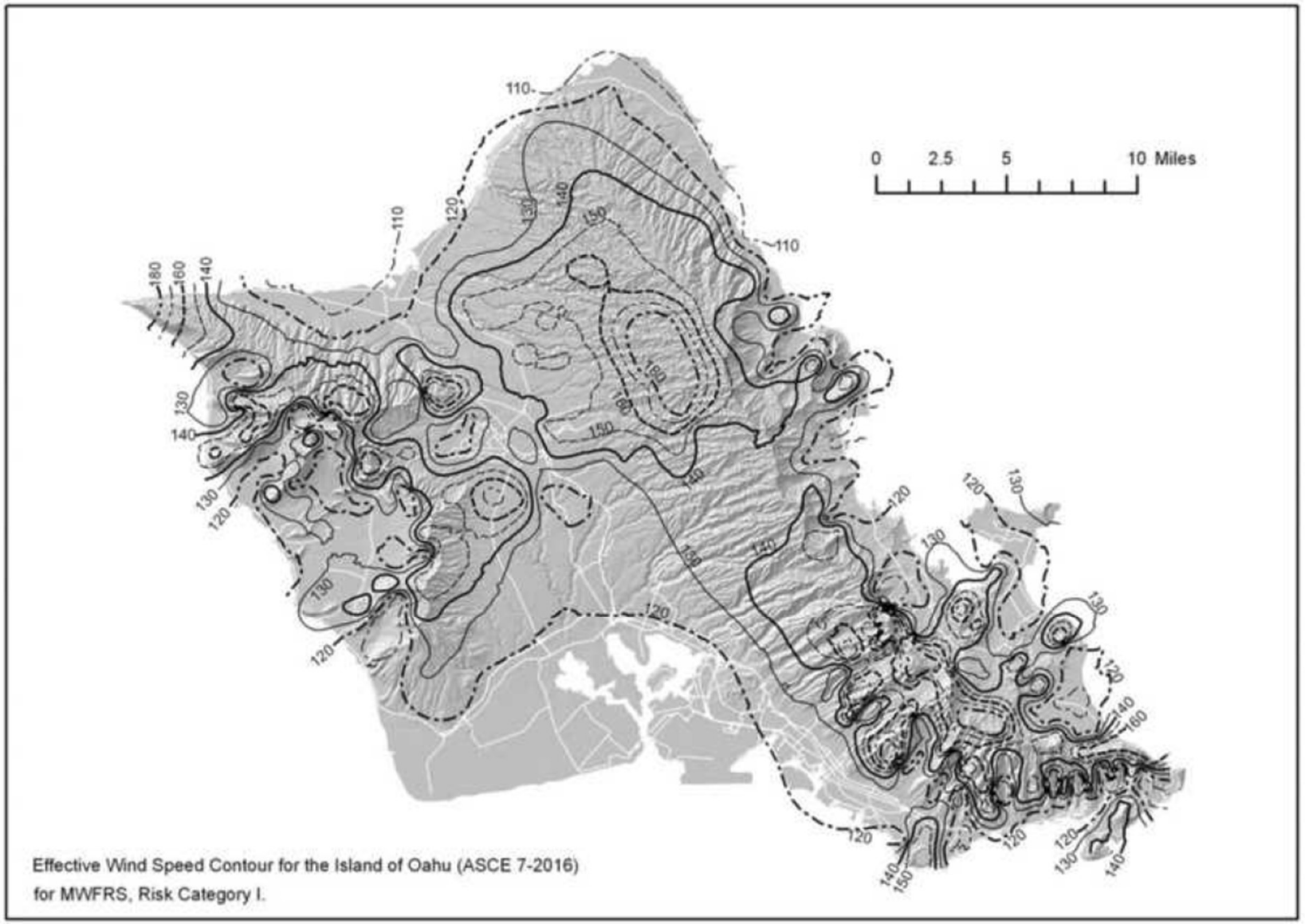


Effective Wind Speed Contour for the Islands of Maui, Molokai and Lanai (ASCE 7-2016)
for MWFRS, Risk Category I

Effective Wind Speed Maps for Hawaii

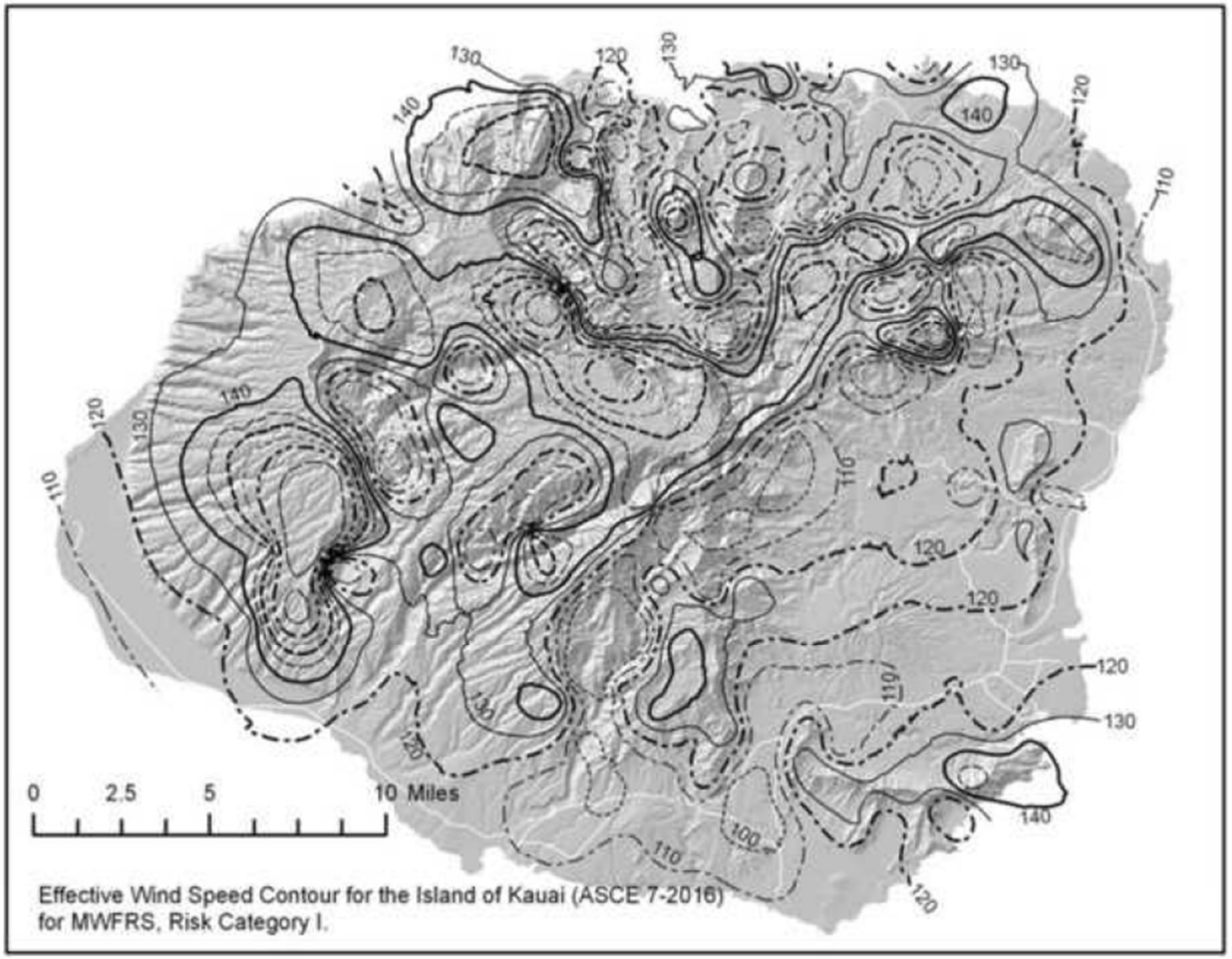


Effective Wind Speed Maps for Oahu



Effective Wind Speed Contour for the Island of Oahu (ASCE 7-2016)
for MWFRS, Risk Category I.

Effective Wind Speed Maps for Kauai



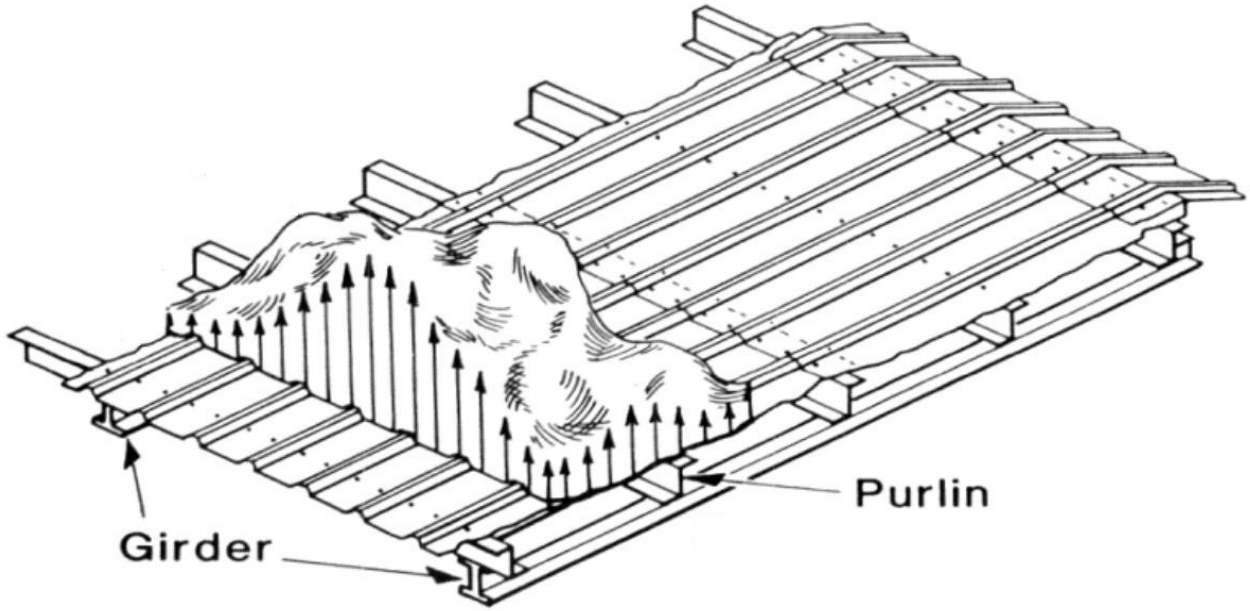
White line Major Road

Effective Wind Speed (mph)

- 100
- 110
- 120
- 130
- 140
- 150
- 160
- 170
- 180
- 200

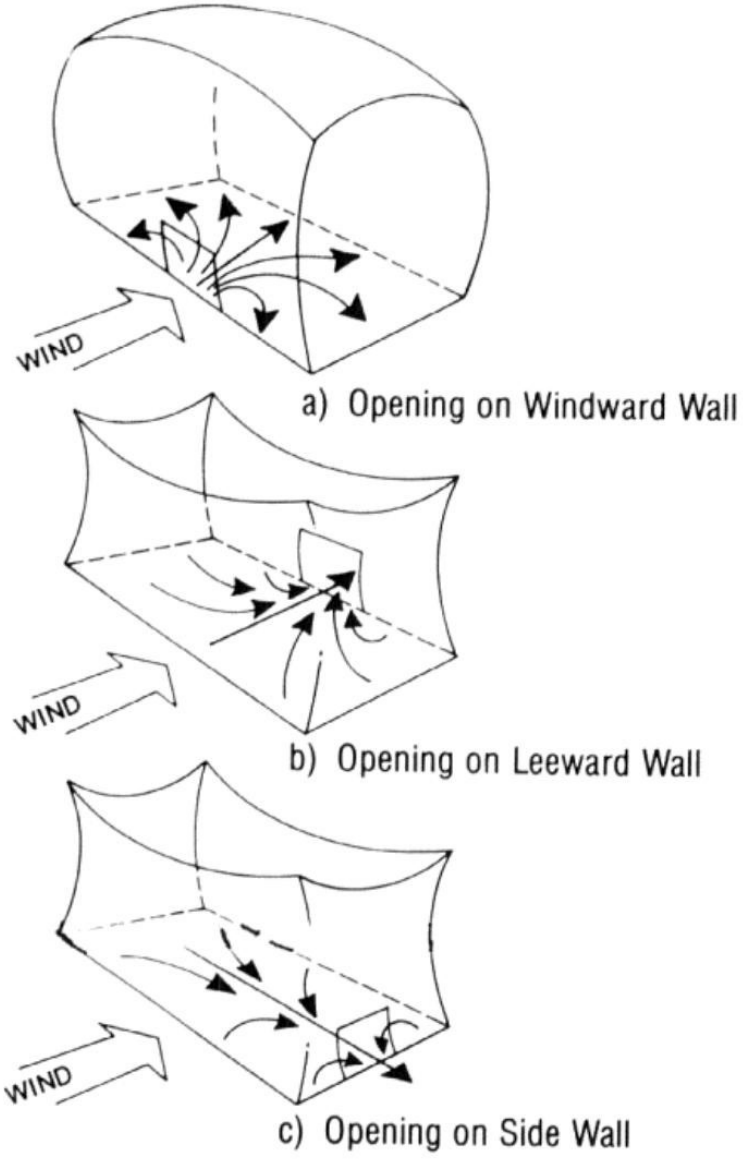
N

C&C Pressure Coefficients



- Area Based Values for Components & Cladding
- For component and cladding elements, the effective area = the span length × effective width that need not be less than one-third the span length.
- For cladding fasteners, effective area ≤ tributary area

Internal Pressure



Enclosure Classification

- Buildings with openings large enough to effect the internal pressure, and with a background porosity low enough to allow that pressure to build up, are classified as partially enclosed.
- Buildings which are at least 80% open on every wall are classified as open.

Enclosure Classification (cont'd)

- Everything else is classified as enclosed.
- A building may have large openings which would allow pressure to enter, but also have enough background porosity that the pressure escapes as fast as it enters. In this case the building is still classified as enclosed.

Basic Wind Equation

- For buildings with External and Internal Pressure:

$$p = qGC_p - q_iGC_{pi}$$

q_i = Velocity pressure calculated for internal pressure.

Evolution of Wind Provisions in U.S. Codes and Standards

- Early building Codes:
  - Uniform pressure of 10 psf and 20 psf below and above 40 ft respectively.
  - Lateral loads only- No uplift provisions.
  - As late as 50 years ago, uplift provisions bore little resemblance to the magnitude of the values used today.

Evolution of Wind Provisions in U.S. Codes and Standards

ANSI A58.1–1972 — Modern wind design in the United States started with ANSI A58.1–1972.

- The provisions represented a quantum jump in sophistication in comparison with codes of practice at that time.
- The provisions were flawed with ambiguities, inconsistencies in terminology, and a format that permitted misinterpretation of certain provisions.

Evolution of Wind Provisions in U.S. Codes and Standards

ANSI A58.1–1982 —

- Revised standard contained an innovative approach to wind forces for components and cladding. The wind-load specification was based on understanding the aerodynamics of wind pressure around building corners, eaves, and ridge areas, as well as the effects of area averaging on pressures.
- This standard was largely free of the ambiguities and inconsistencies of ANSI A58.1-1972 and began to be adopted by model code organizations.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-88 — The first minimum-loads standard to appear under ASCE's banner was ASCE 7-88, in which only minor changes and modifications were made in the wind provisions of ANSI A58.1-1982.

ASCE 7-93 — No changes whatsoever were made to the wind provisions in the next edition of the standard, ASCE 7-93.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-95 — The most significant since 1982; a number of important changes made.

- 3-sec gust wind speed became the basis of design. The design wind speed, which for the vast majority of the country had been 70 miles per hour (mph), now became 90 mph, except in the West (roughly in the Pacific time zone), where it typically became 85 mph.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-95 — Important changes (Contd.)

- In order not to end up with significantly greater design wind pressures as a result of this change, numerous adjustments had to be made to coefficients. Some of the more important of these included velocity pressure exposure coefficients, gust-effect factors, and internal and external pressure coefficients that included gust effects.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-95 — Important changes (Contd.)

- Provisions were added for wind speed-up over isolated hills and escarpments by including a topographic-effect factor in the expression for velocity pressure.
- New provisions were added for full and partial loading on the MWFRS of buildings with a mean roof height greater than 60 ft, thereby requiring consideration of wind-induced torsion in all buildings other than low-rise buildings.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-95 — Important changes (Contd.)

- An alternate (low-rise, analytical) procedure was added for determining external loads on the MWFRSs of buildings having mean roof height not exceeding 60 ft. This procedure had been adopted into the Standard Building Code (SBC) from the Metal Building Manufacturers' Association (MBMA) manual and was based on testing carried out at the University of Western Ontario, in London, Ontario, many years earlier.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-98 —

- The basic wind-speed map was updated based on new analysis of hurricane wind speeds. As a result, wind speeds became significantly lower in inland Florida.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-98 —

- A wind-directionality factor, K_d, was introduced in the expression for the design wind pressure to account for the directionality of wind. Directionality used to be taken into account through a relatively low load factor of 1.3 on the effect of wind in strength design. the 1.3 load factor on wind was adjusted up. A load factor of 1.3/0.85 = 1.53 would have maintained status quo exactly. However, it was rounded up to 1.6, which resulted in an effective 5 percent increase in the wind-load factor. For ASD, the effect of this change was 15 percent lower wind forces.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-98 —

- The definitions of Exposures C and D were changed slightly to allow the shorelines in hurricane-prone regions to be classified as Exposure C rather than Exposure D.
- A simplified design procedure was introduced for the first time for relatively common low-rise (mean roof height not exceeding 30 ft), regular-shaped, simple diaphragm buildings. New definitions were introduced for regular-shaped buildings and simple diaphragm buildings.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-98 —

- For the first time, the wind design provisions were organized by the method of design: Method 1 – Simplified Procedure; Method 2 – Analytical Procedure; and Method 3 – Wind Tunnel Procedure. Method 2 contained two separate and distinct procedures under the same heading — the general analytical procedure, applicable to buildings of all heights, and the low-rise analytical procedure, applicable to buildings having mean roof height not exceeding 60 ft.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-98 —

- A very important provision was introduced, requiring that glazing in the lower 60 ft of Category II, III, or IV buildings (all buildings except those representing a low hazard to human life in the event of failure) sited in wind-borne debris regions be impact-resistant glazing or protected with an impact-resistant covering, or such glazing that receives positive external pressure be assumed to be openings. "Wind-borne debris region" was defined in ASCE 7-98.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-02 —

- In ASCE 7-02, the simplified design procedure, Method 1, of ASCE 7-98 was discarded. The simplified design procedure in Section 1609.6 of the 2000 IBC, with only a few relatively minor modifications, was adopted instead. This simplified procedure is based on the low-rise analytical procedure of ASCE 7 and bears strong resemblance to it. Its applicability is broader than that of the simplified design procedure in ASCE 7-98.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-02 —

- ASCE 7-02 required that a ground-surface roughness within each 45-degree sector be determined for a distance upwind of the site. Three surface-roughness categories were defined as shown in *Table 1*.
- Three exposure categories were defined in terms of the three roughness categories. The former Exposure A (centers of large cities) was deleted.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-02 —

- Provisions for calculating wind loads on parapets were added.
- Consideration of wind-induced torsion was now required for all buildings, not just buildings having mean roof height exceeding 60 ft.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-05 —

- ASCE 7-02 required Exposure D to extend inland from the shoreline for a distance of 660 ft or 10 times the height of the building, whichever was greater. ASCE 7-05 required Exposure D to extend into downwind areas of Surface Roughness B or C for a distance of 600 ft or 20 times the height of the building, whichever is greater. Other controlling distances were rounded off to the nearest 100 ft.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-05 —

- Glazing in wind-borne debris regions that receive positive external pressure could no longer be treated as openings for design purposes, instead of making it impact-resistant or protected.
- Provisions for wind loads on parapets were updated. Values of the Combined Net Pressure Coefficient were updated from +1.8 and -1.1 to +1.5 and -1.0 for windward and leeward parapets, respectively.

Evolution of Wind Provisions in U.S. Codes and Standards

ASCE 7-05 —

- Design wind loads on free-standing walls and solid signs were revised.
- Design wind loads on open buildings with monoslope roofs were revised. Design wind loads on open buildings with pitched or troughed roofs were provided for the first time.
- New provisions were added for rooftop structures and equipment when the roof height of the building is less than 60 ft.

ASCE 7-10 Reorganization of Wind Provisions

- ASCE 7-05: Chapter 6 contained all wind provisions
- ASCE 7-10:
  - 6 new Chapters (Chapters 26-31)
  - User Notes added
  - Intent was to clarify the applicability of the wind provisions

Reorganization of Wind Provisions
(ASCE 7-05: Red; ASCE 7-10: Dark Gray)

Method 1 – Envelope Procedure MWFRS, C&C
(Simplified Method 2 Low-Rise)

Method 2

- All-Heights – Directional Procedure MWFRS, C&C
- Low-Rise – Envelope Procedure MWFRS, C&C

Method 3 – Wind Tunnel Procedure

Reorganization of Wind Provisions
(ASCE 7-05: Red; ASCE 7-10: Dark Gray)

Chapter 26 – General Requirements

Chapter 27 – MWFRS Directional Procedure

Method 2 All-Heights, new simplified version - MWFRS

Chapter 28 – MWFRS Envelope Procedure

Method 2 Low-Rise, Method 1 - MWFRS

Chapter 29 – MWFRS Other Structures and Appurtenances

Chapter 30 – C&C **Method 2 All-Heights, Method 1, new simplified version of Method 2 All-Heights – C&C**

Chapter 31 – Wind Tunnel Procedure **Method 3**

ASCE 7-10 Section 26.7.2
Surface Roughness Categories

Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 30 ft. This category includes flat open country, and grasslands, and ~~all water surfaces in hurricane prone regions~~.

Surface Roughness D: Flat, unobstructed areas and water surfaces ~~outside hurricane prone regions~~. This category includes smooth mud flats, salt flats, and unbroken ice.

ACE 7-10 Section 26.7.2
Surface Roughness Categories

ASCE 7-10 Section 26.7.2
Surface Roughness Categories

- Water surfaces in hurricane-prone regions are moved from Surface Roughness C to Surface Roughness D.
- Older research and modeling suggested roughness of ocean approached Surface Roughness C with increase in wind speed.
- New research suggests otherwise - roughness of ocean does not continue to increase with increasing wind speed.

Rigid vs. Flexible Buildings

BUILDING OR OTHER STRUCTURE, FLEXIBLE: Slender buildings and other structures that have a fundamental natural frequency less than 1 Hz (T_1>1 sec).

BUILDING OR OTHER STRUCTURE, RIGID: A building or other structure whose fundamental frequency is greater than or equal to 1 Hz.1 (T_1≤1 sec)

$$T_1(\text{sec}) = 1/f_1(\text{sec}^{-1} \text{ or Hz})$$

ASCE 7-10 Section 26.9.2 Frequency Determination

- In ASCE 7-05, several expressions for computing approximate fundamental frequency , n_1, of a building were suggested in C6.5.8.
- Some of those expressions were now included within the body of ASCE 7-10
- Expressions provide conservative lower-bound estimates of n_1, which is needed to distinguish between rigid and flexible buildings.
- Low-Rise Buildings, as defined in 26.2, are permitted to be considered rigid.

ASCE 7-10 Section 26.9.2 Frequency Determination

26.9.2.1. As an alternative to performing an analysis to determine n_1, the approximate building natural frequency, n_a, shall be permitted to be calculated in accordance with 26.9.3 for structural steel, concrete, or masonry buildings meeting the following requirements:

ASCE 7-10 Section 26.9.2 Frequency Determination

26.9.2.1 May use n_a for n_1 if

1. Building height is less than or equal to 300 ft, and
2. Building height is less than 4 times its effective length, L_{eff}.

$$L_{eff} = \frac{\sum_{i=1}^{n} h_i L_i}{\sum_{i=1}^{n} h_i} \qquad (26.9\text{-}1)$$

summations are over height of building where
h_i is height above grade of level i
L_i is building length at level i parallel to wind direction

ASCE 7-10 Section 26.9.3 Approximate Natural Frequency

- Structural steel moment-resisting-frame buildings:

$$n_a = 22.2/h^{0.8} \qquad (26.9\text{-}2)$$

- Concrete moment-resisting-frame buildings:

$$n_a = 43.5/h^{0.9} \qquad (26.9\text{-}3)$$

- Structural steel and concrete buildings with other lateral-force-resisting system:

$$n_a = 75/h \qquad (26.9\text{-}4)$$

ASCE 7-10 Section 26.9.3 Approximate Natural Frequency

- Concrete or masonry shear wall buildings

$$n_a = 385(C_w)^{0.5}/h \qquad (26.9\text{-}5)$$

where

$$C_w = \frac{100}{A_B}\sum_{i=1}^{n}\left(\frac{h}{h_i}\right)^2 \frac{A_i}{\left[1+0.83\left(\frac{h_i}{D_i}\right)^2\right]}$$

ASCE 7-10 Section 26.9.3 Approximate Natural Frequency

h = mean roof height (ft)

n = number of shear walls in building effective in resisting lateral forces in direction under consideration

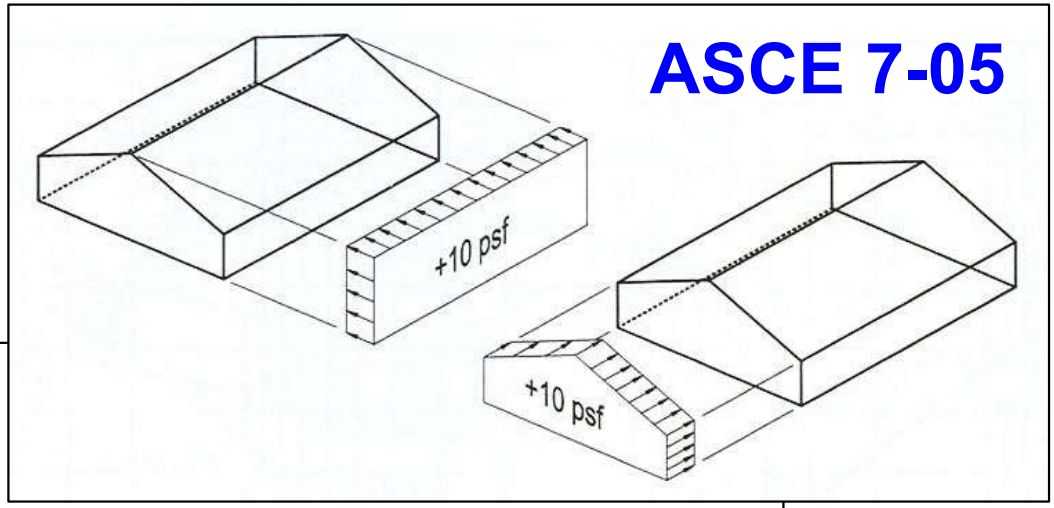
A_B = base area of structure (ft^2)

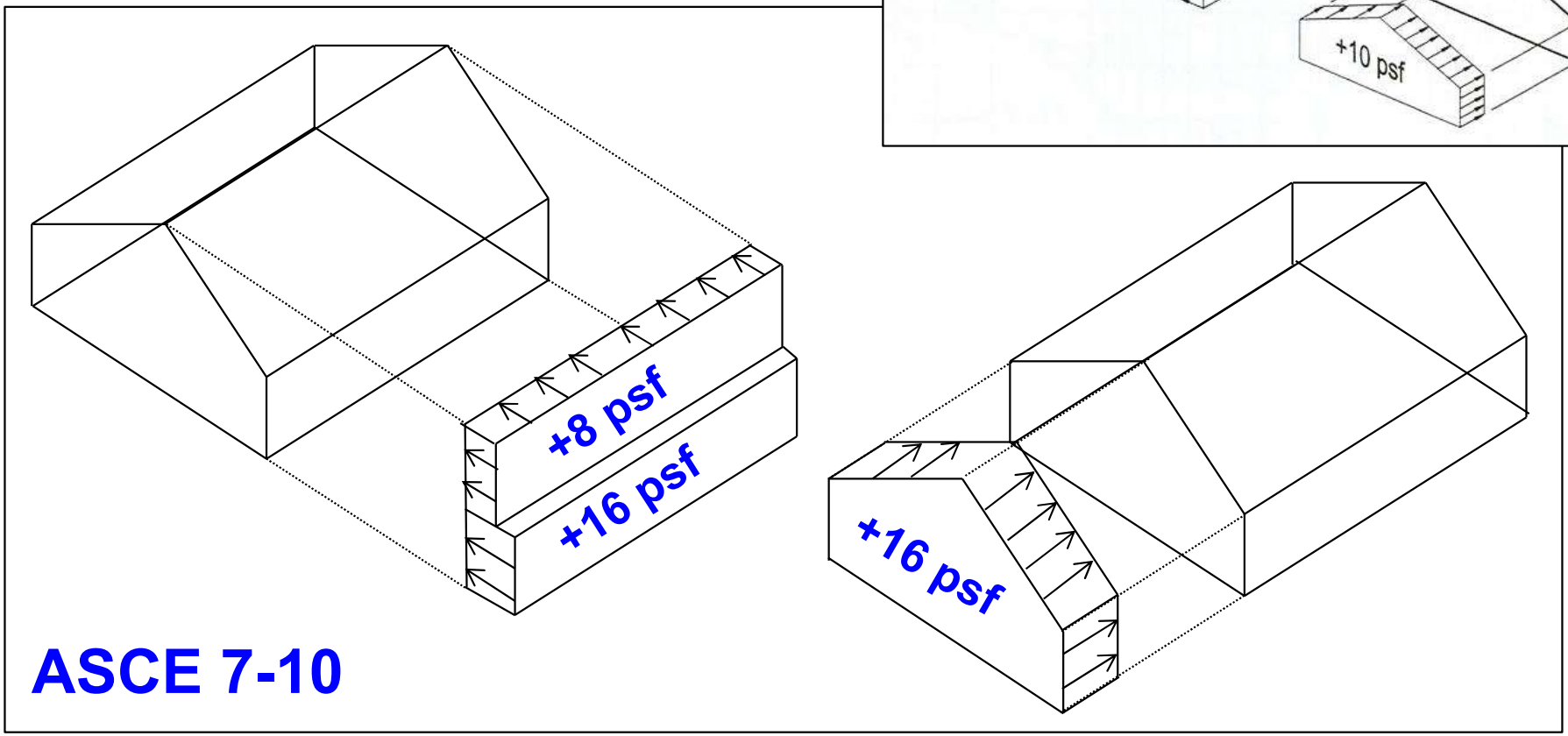
A_i = horizontal cross-section area of shear wall "i" (ft^2)

D_i = length of shear wall "i" (ft)

h_i = height of shear wall "i" (ft)

27.4.7, 28.4.4, 28.6.4
Minimum Design Wind Loads





ASCE 7-16 Velocity Pressure

$$q_z = 0.00256 K_z K_{zt} K_d \mathbf{K_e} V^2 \text{ (lb/ft}^2\text{)};\ V \text{ in mph} \qquad (26.10\text{-}1)$$

ASCE 7-16 Elevation Factor

26.9 Ground Elevation above Sea Level

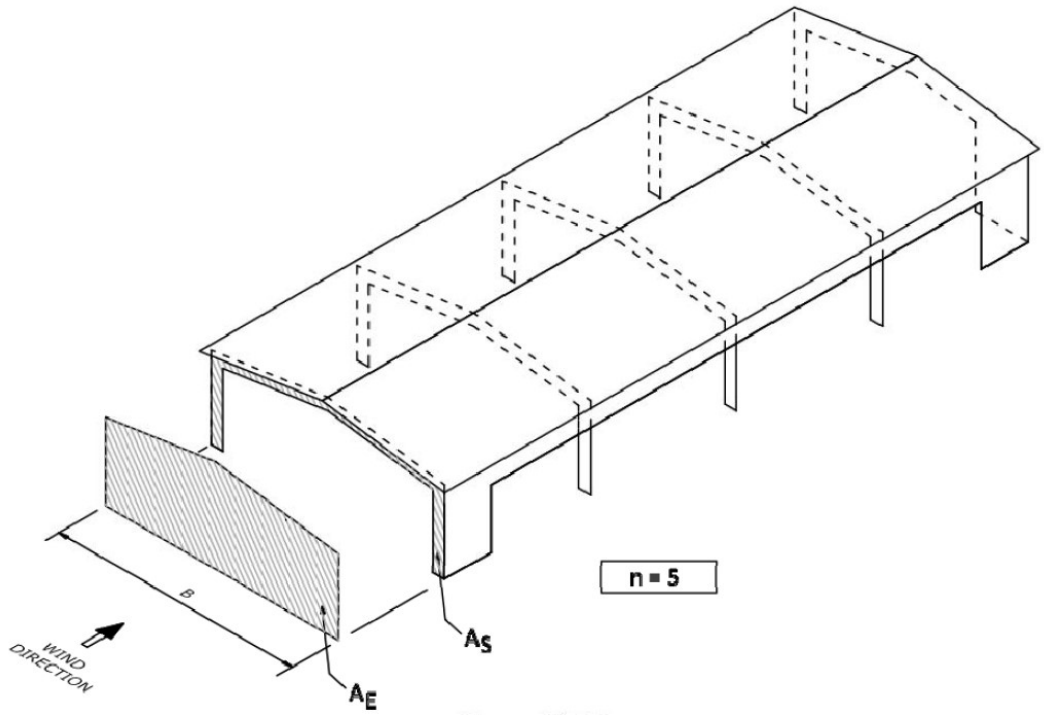
The effect on air density caused by elevation of the ground level at the project site above sea level is accounted for by the factor K_e, obtained from Table 26.9-1.

Ground Elevation above Sea Level	K_e
0	1.00
1000	0.96
2000	0.93
3000	0.90
4000	0.86
5000	0.83
6000	0.80

ASCE 7-16 Ch. 28 Envelope Procedure for MWFRS

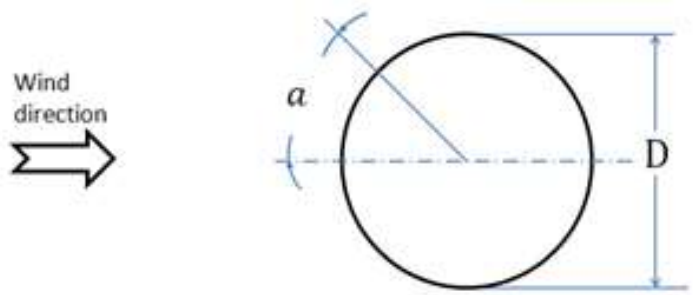
In Part 1, new section added:

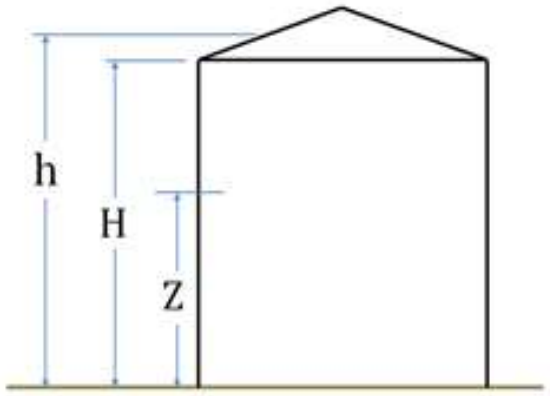
28.3.5 Horizontal Wind Loads on Open or Partially Enclosed Buildings with Transverse Frames and Pitched Roofs.

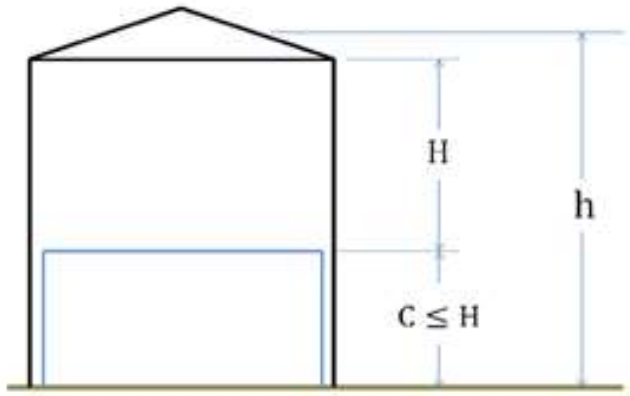


ASCE 7-16 Circular Bins, Silos, and Tanks

29.4.2 Design Wind Loads: Circular Bins, Silos, and Tanks with $h \leq 120$ ft, $D \leq 120$ ft, and $0.25 \leq H/D \leq 4$.







ASCE 7-16 Circular Bins, Silos, and Tanks

29.4.2 Design Wind Loads: Circular Bins, Silos, and Tanks with $h \leq 120$ ft, $D \leq 120$ ft, and $0.25 \leq H/D \leq 4$.

ASCE 7-16 Rooftop Solar Collectors

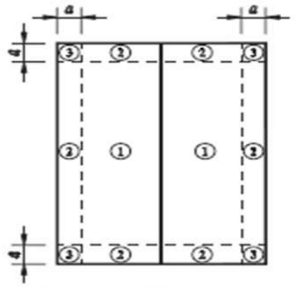
29.4.3 Rooftop Solar Arrays for Buildings of All Heights with Flat Roofs or Gable or Hip Roofs with Slopes Less Than 7°.

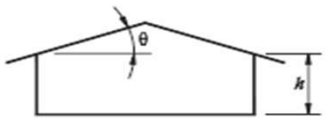
ASCE 7-16 30 Components and Cladding - Gable Roofs (Low-Rise Analytical)

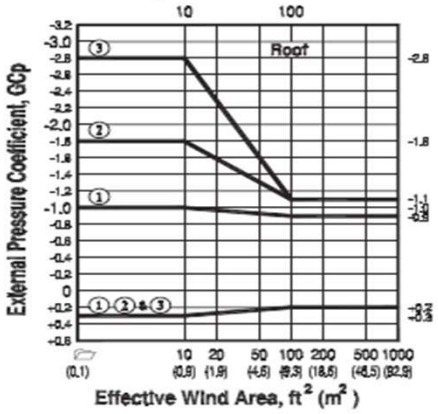
Components and Cladding | **h ≤ 60 ft.**

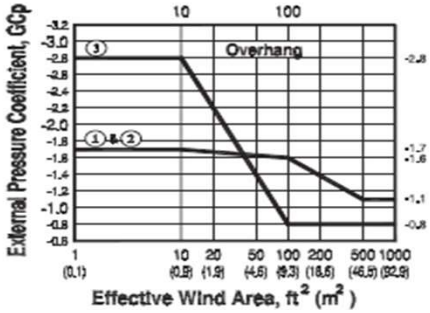
Figure 30.4-2A | **External Pressure Coefficients, GC_p**

Enclosed, Partially Enclosed Buildings | **Gable Roofs θ ≤ 7°**







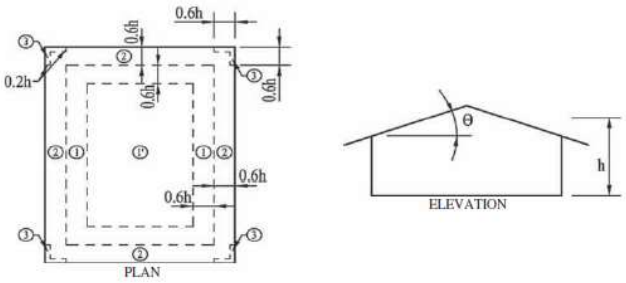


Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. If a parapet equal to or higher than 3 ft (0.9m) is provided around the perimeter of the roof with θ ≤ 7°, the negative values of GC_p in Zone 3 shall be equal to those for Zone 2 and positive values of GC_p in Zones 2 and 3 shall be set equal to those for wall Zones 4 and 5 respectively in Figure 30.4-1.
6. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
7. Notation:
   - a: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - h: Eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

ASCE 7-10

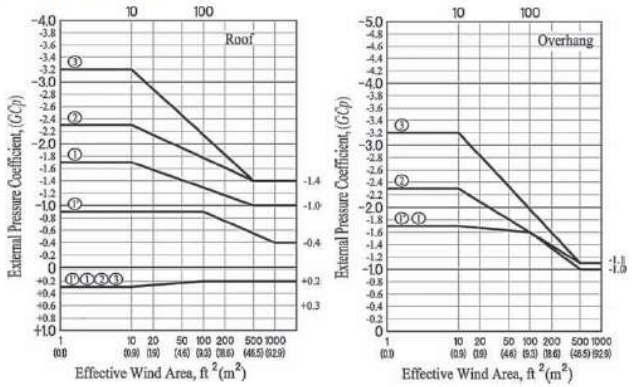
Diagrams



Notation

B = Horizontal dimension of building measured normal to wind direction, in ft (m).
h = Eave height shall be used for θ = 10°.
θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients



Notes

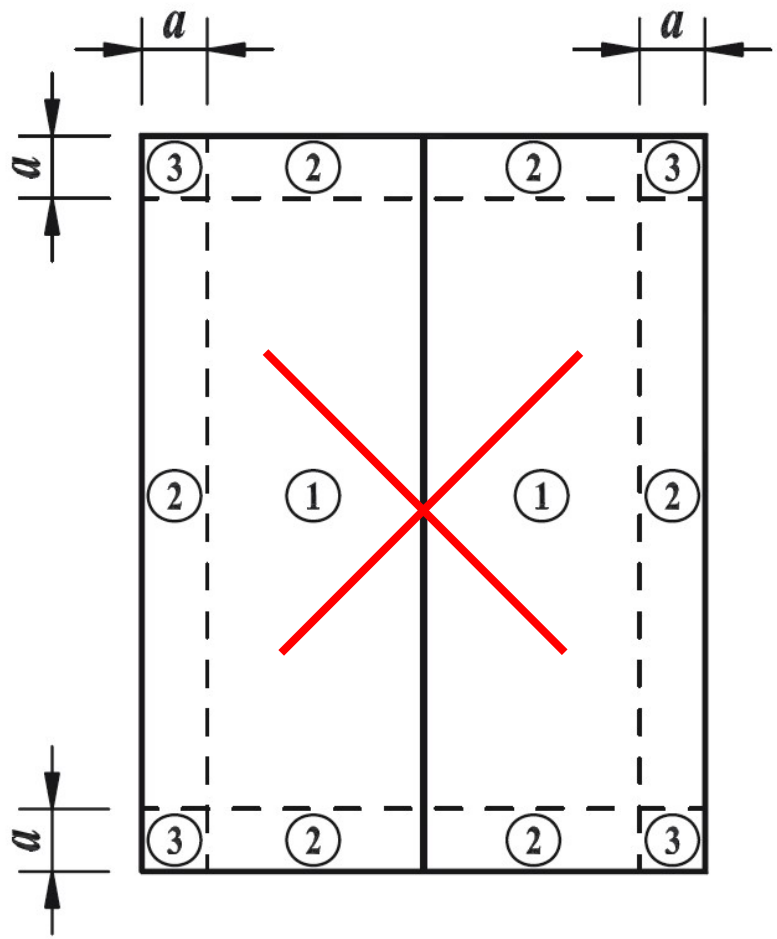
1. Vertical scale denotes (GC_P) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. If a parapet equal to or higher than 3 ft (0.9 m) is provided around the perimeter of the roof with θ ≤ 7°, the negative values of (GC_P) in Zone 3 shall be equal to those for Zone 2, and positive values of (GC_P) in Zones 2 and 3 shall be set equal to those for wall Zones 4 and 5, respectively, in Fig. 30.3-1.
6. Values of (GC_P) for roof overhangs include pressure contributions from both upper and lower surfaces.
7. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, a, shall be measured from the outside edge of the overhang.

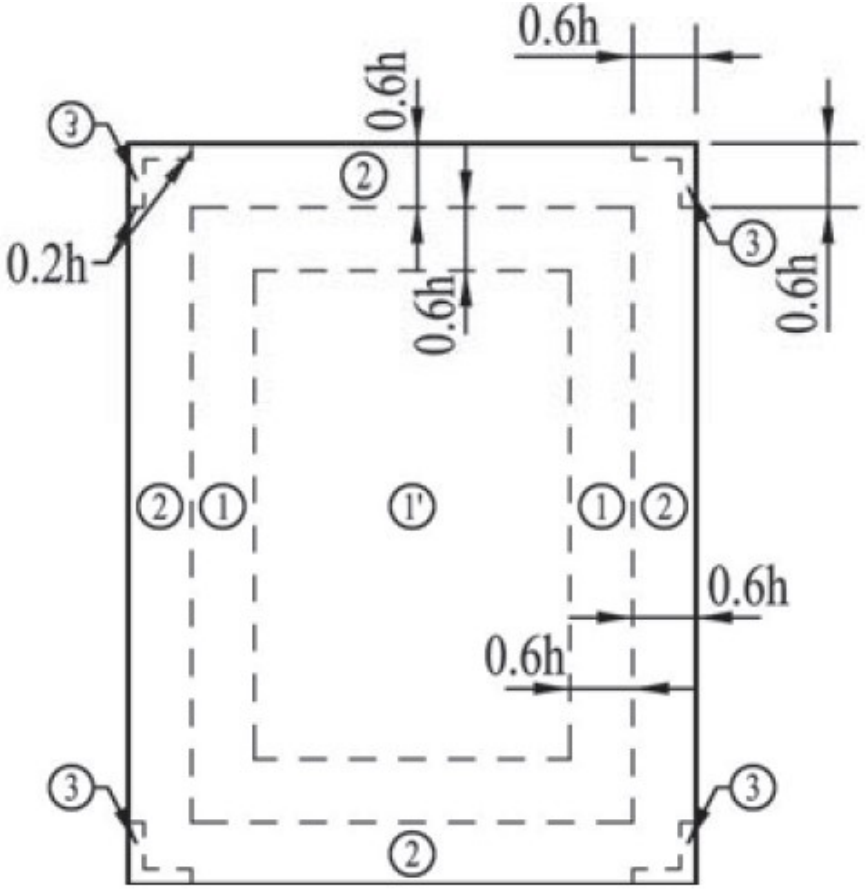
FIGURE 30.3-2A Components and Cladding [$h \leq 60$ ft ($h \leq 18.3$ m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Gable Roofs, θ ≤ 7°

ASCE 7-16

ASCE 7-16 30 Components and Cladding - Gable Roofs (Low-Rise Analytical)

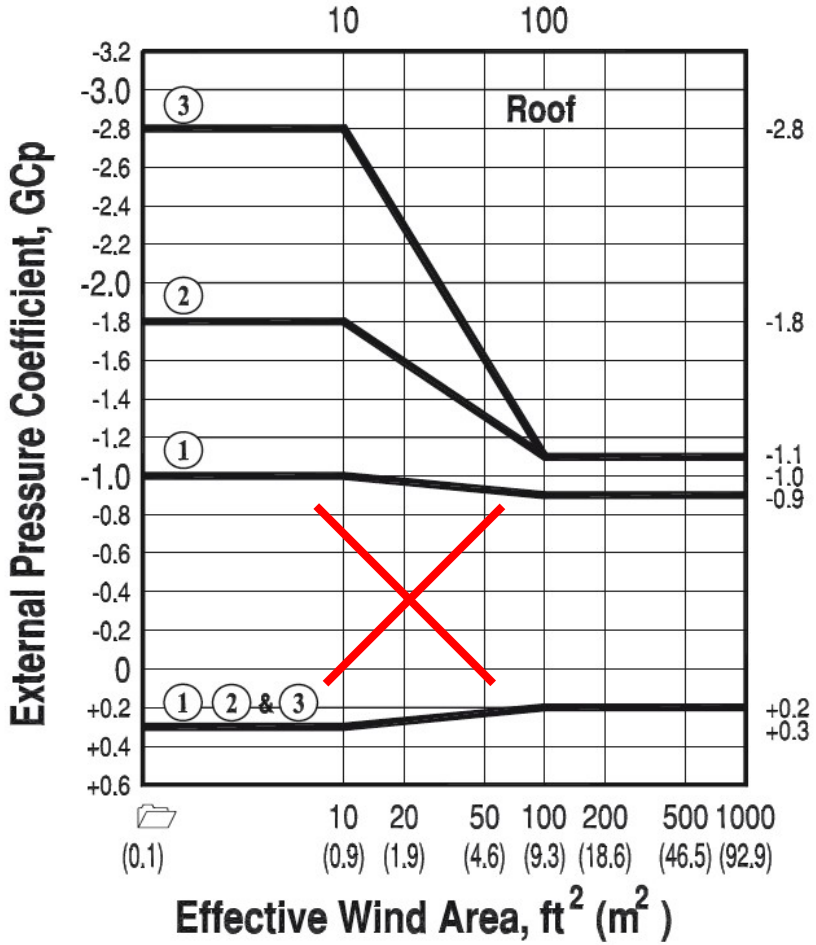
Components and Cladding		$h \leq 60$ ft
Figure 30.43-2A	External Pressure Coefficients, GC_p	Gable Roofs $\theta \leq 7°$
Enclosed, Partially Enclosed Buildings		

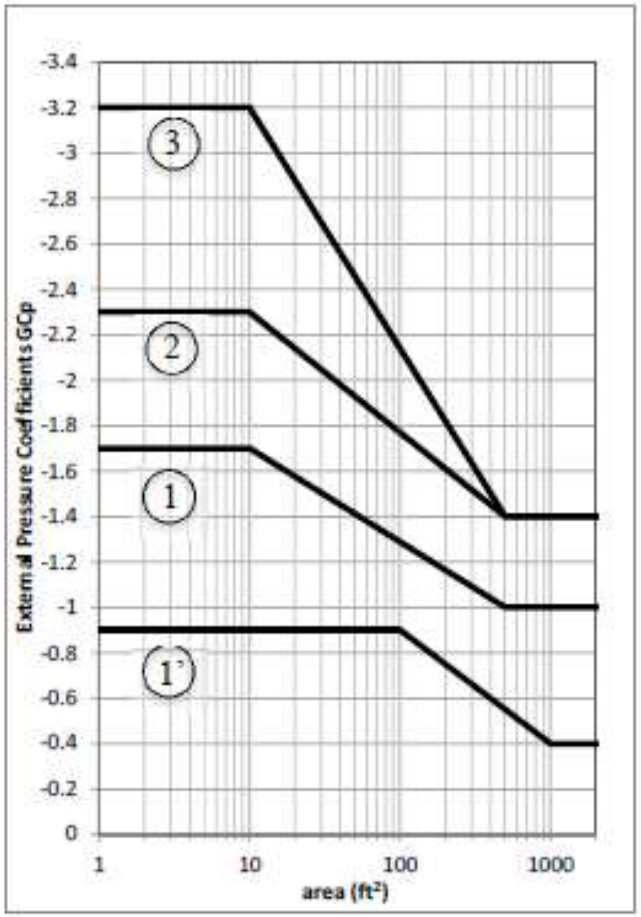




ASCE 7-16 30 Components and Cladding - Gable Roofs (Low-Rise Analytical)

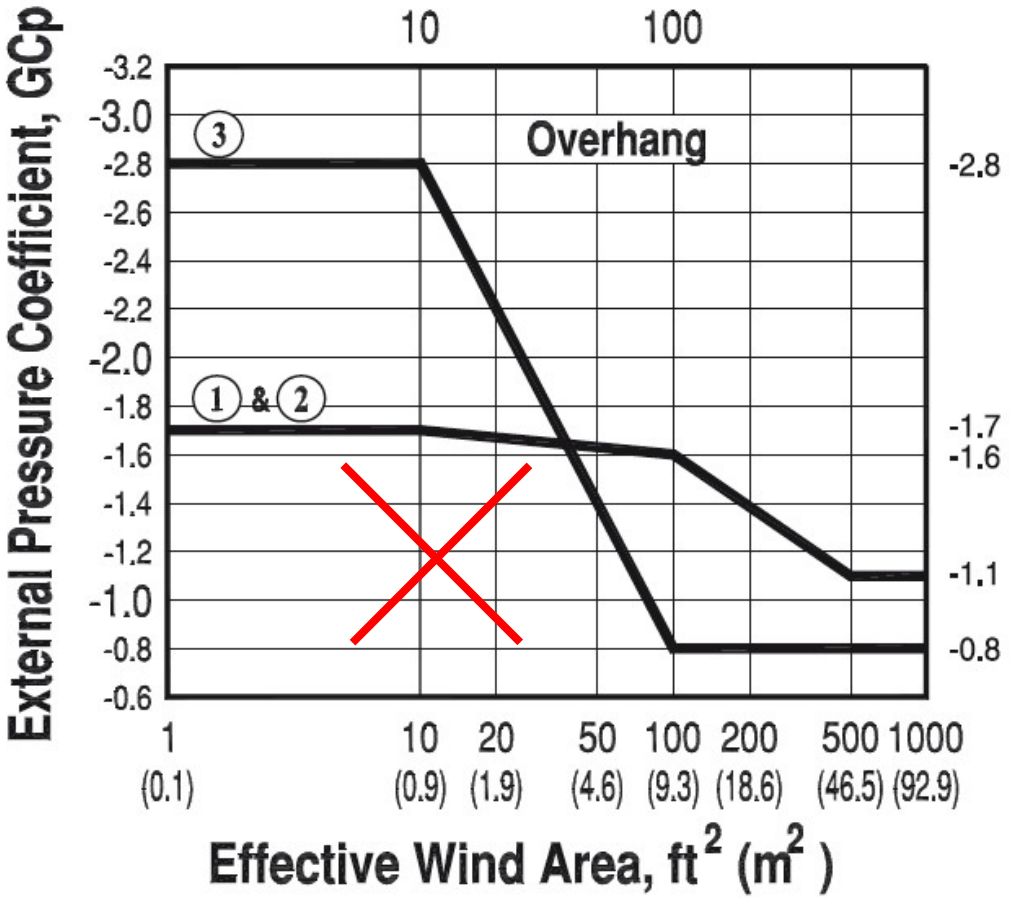
Components and Cladding		$h \leq 60$ ft
Figure 30.43-2A	External Pressure Coefficients, GC_p	Gable Roofs $\theta \leq 7°$
Enclosed, Partially Enclosed Buildings		

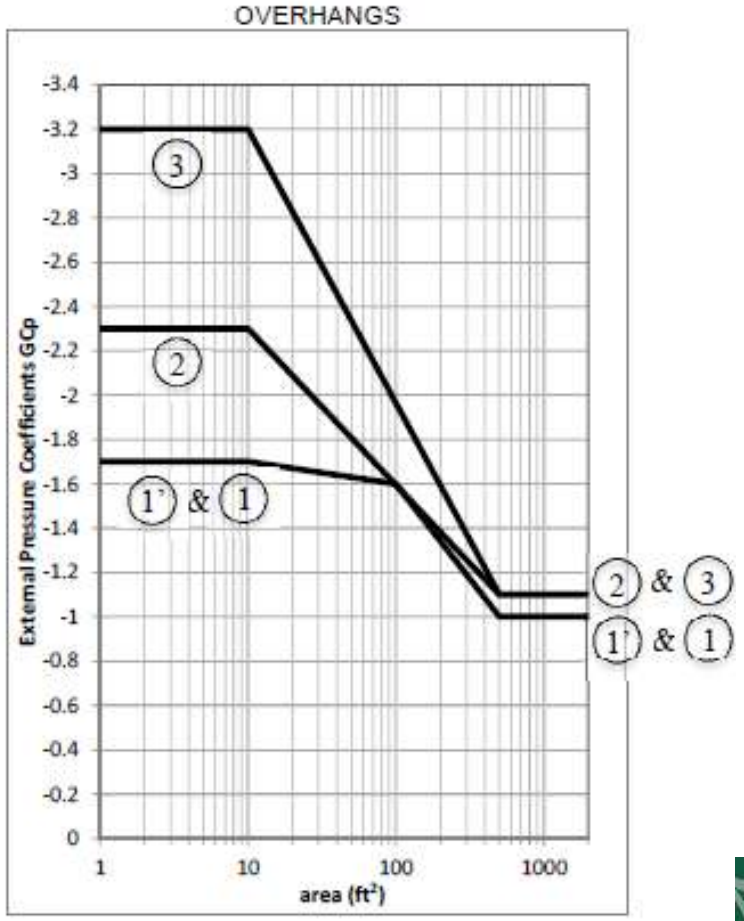




ASCE 7-16 30 Components and Cladding - Gable Roofs (Low-Rise Analytical)

Components and Cladding		$h \leq 60$ ft
Figure 30.43-2A	External Pressure Coefficients, GC_p	Gable Roofs $\theta \leq 7°$
Enclosed, Partially Enclosed Buildings		



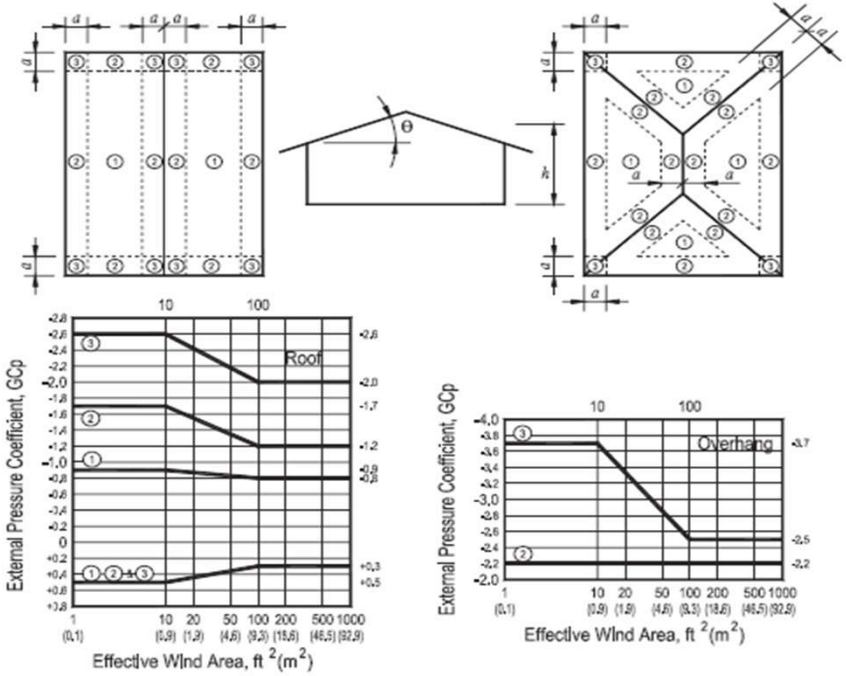


ASCE 7-16 30 C & C - Gable/Hip Roofs (Low-Rise Analytical)

Components and Cladding | **h ≤ 60 ft.**

Figure 30.4-2B | **External Pressure Coefficients, GC_p**

Enclosed, Partially Enclosed Buildings | **Gable/Hip Roofs 7°< θ ≤ 27°**

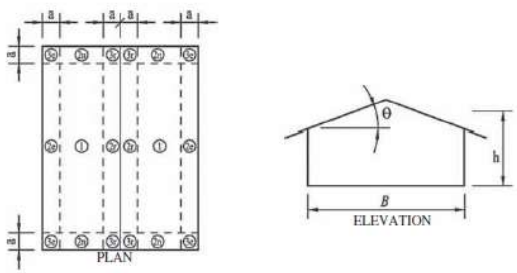


Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. Notation:
   - *a*: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - *h*: Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

ASCE 7-10

Diagrams



Notation

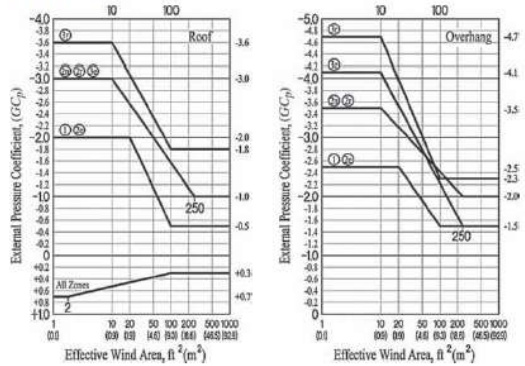
a = 10% of least horizontal dimension or 0.4*h*, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m). If an overhang exists, the edge distance shall be measured from the outside edge of the overhang. The horizontal dimensions used to compute the edge distance shall not include any overhang distances.

B = Horizontal dimension of building measured normal to wind direction, in ft (m).

h = Mean roof height, in ft (m), except that eave height shall be used for θ ≤ 10°.

θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients



Notes

1. Vertical scale denotes (GC_p) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of (GC_p) for roof overhangs include pressure contributions from both upper and lower surfaces.
6. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, *a*, shall be measured from the outside edge of the overhang.

FIGURE 30.3-2B Components and Cladding [$h \le 60$ ft ($h \le 18.3$ m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Gable Roofs, 7° < θ ≤ 20°

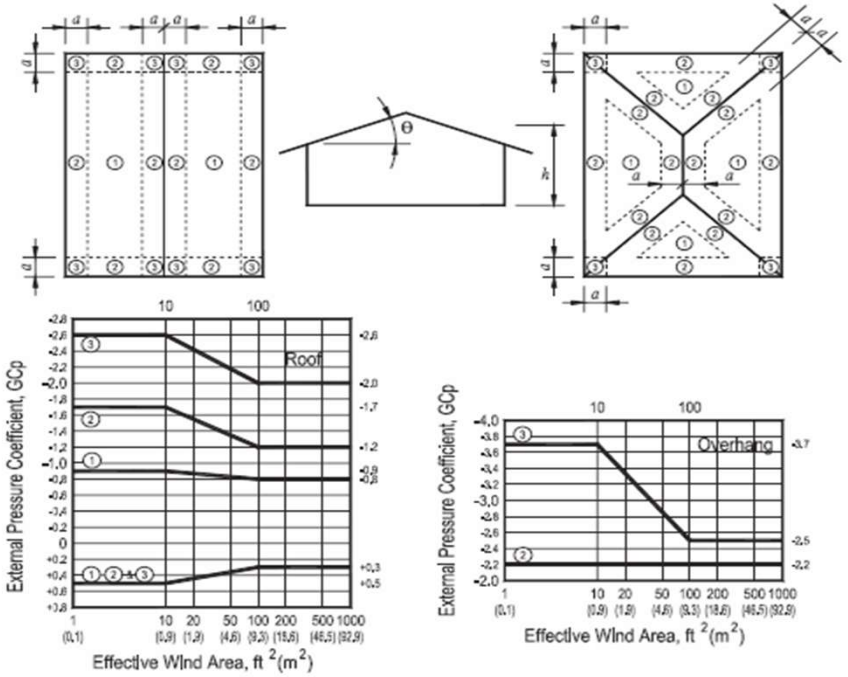
ASCE 7-16

ASCE 7-16 30 C & C - Gable/Hip Roofs (Low-Rise Analytical)

Components and Cladding | **h ≤ 60 ft.**

Figure 30.4-2B | **External Pressure Coefficients, GC_p**

Enclosed, Partially Enclosed Buildings | **Gable/Hip Roofs 7°< θ ≤ 27°**

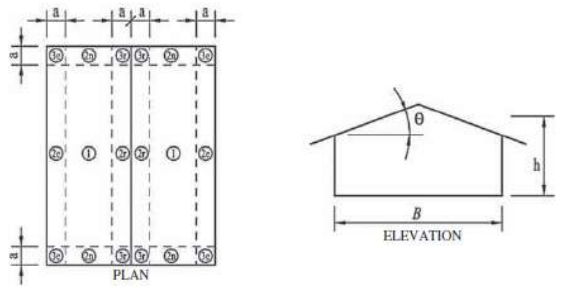


Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. Notation:
   - *a*: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - *h*: Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

ASCE 7-10

Diagrams



Notation

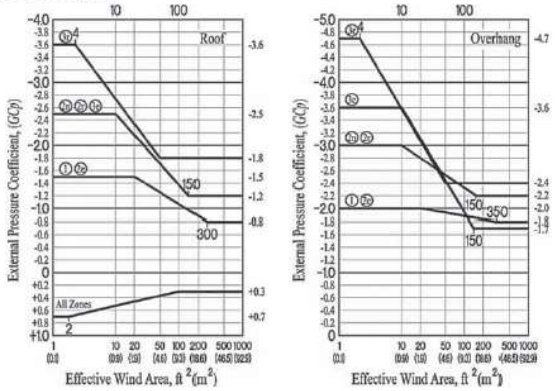
a = 10% of least horizontal dimension or 0.4*h*, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m). If an overhang exists, the edge distance shall be measured from the outside edge of the overhang. The horizontal dimensions used to compute the edge distance shall not include any overhang distances.

B = Horizontal dimension of building measured normal to wind direction, in ft (m).

h = Mean roof height, in ft (m).

θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients



Notes

1. Vertical scale denotes (GC_p) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of (GC_p) for roof overhangs include pressure contributions from both upper and lower surfaces.
6. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, *a*, shall be measured from the outside edge of the overhang.

FIGURE 30.3-2C Components and Cladding [$h \le 60$ ft ($h \le 18.3$ m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Gable Roofs, $20° < \theta \le 27°$

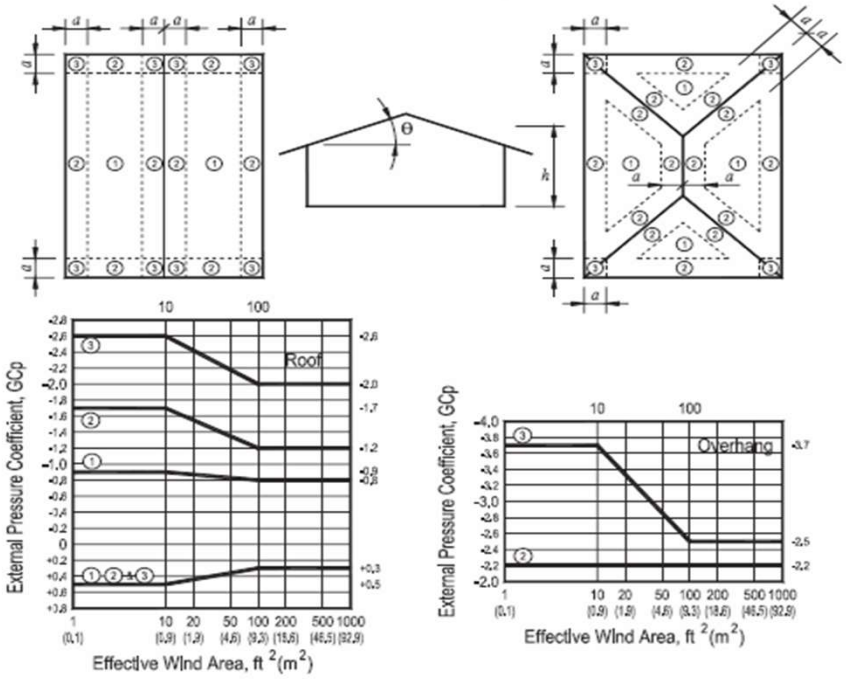
ASCE 7-16

ASCE 7-16 30 C & C - Gable/Hip Roofs (Low-Rise Analytical)

Components and Cladding | **h ≤ 60 ft.**

Figure 30.4-2B | **External Pressure Coefficients, GC_p**

Enclosed, Partially Enclosed Buildings | **Gable/Hip Roofs 7°< θ ≤ 27°**

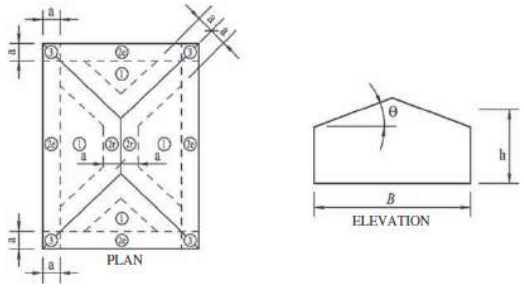


Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. Notation:
   - *a*: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - *h*: Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

ASCE 7-10

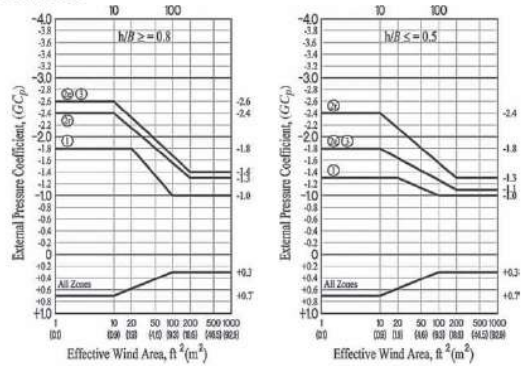
Diagrams



Notation

a = 10% of least horizontal dimension or 0.4*h*, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m). If an overhang exists, the edge distance shall be measured from the outside edge of the overhang. The horizontal dimensions used to compute the edge distance shall not include any overhang distances.
h = Mean roof height, in ft (m), except that eave height shall be used for θ ≤ 10°.
B = Horizontal dimension of building measured normal to wind direction, in ft (m).
θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients



Notes

1. Vertical scale denotes (GC_P) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, *a*, shall be measured from the outside edge of the overhang.
6. Interpolation of (GC_P) between the two different *h*/*B* values is required for 0.5 < *h*/*B* < 0.8.
7. *B* for Zone 3 is the least horizontal dimension. *B* for Zones 1 and 2e is normal to the building width and normal to the eave defining Zone 2e.

FIGURE 30.3-2E Components and Cladding [$h \le 60$ ft ($h \le 18.3$ m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Hip Roofs, 7°< θ ≤ 20° (Roof)

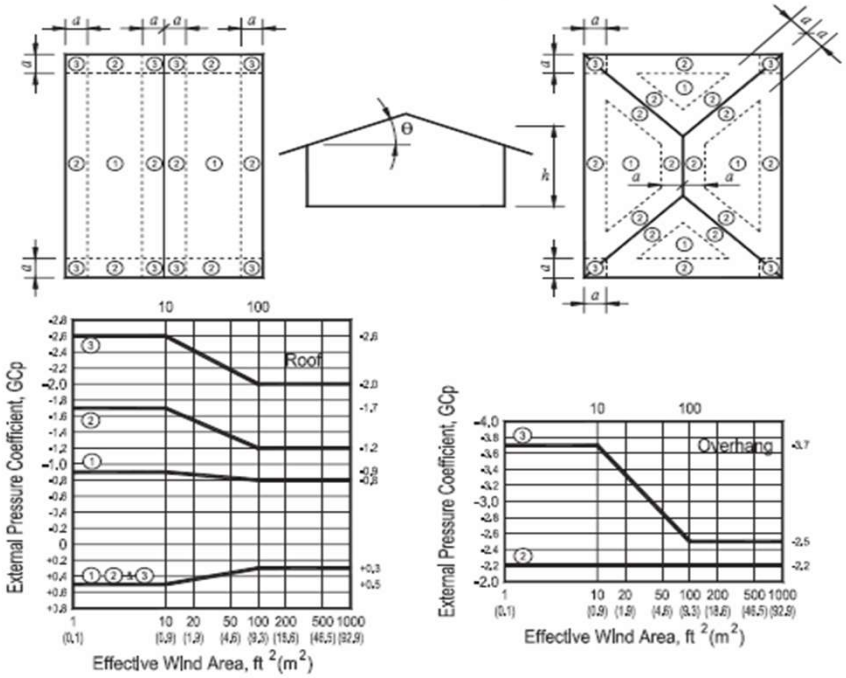
ASCE 7-16

30 Components and Cladding Hip Roofs

Components and Cladding | **h ≤ 60 ft.**

Figure 30.4-2B | **External Pressure Coefficients, GC_p**

Enclosed, Partially Enclosed Buildings | **Gable/Hip Roofs 7°< θ ≤ 27°**

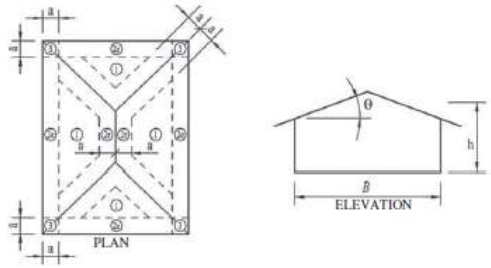


Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. Notation:
   - a: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - h: Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

ASCE 7-10

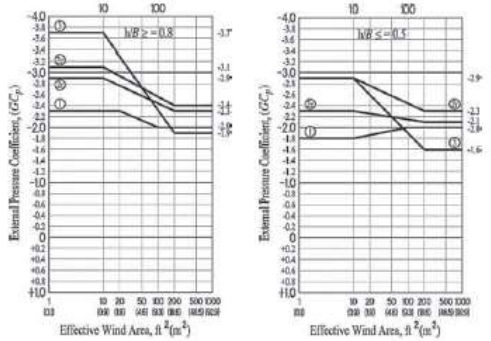
Diagrams



Notation

a = 10% of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m). If an overhang exists, the edge distance shall be measured from the outside edge of the overhang. The horizontal dimensions used to compute the edge distance shall not include any overhang distances.
h = Mean roof height, in ft (m), except that eave height shall be used for θ ≤ 10°.
B = Horizontal dimension of building measured normal to wind direction, in ft (m).
θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients



Notes

1. Vertical scale denotes (GC_P) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of (GC_P) for roof overhangs include pressure contributions from both upper and lower surfaces.
6. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, a, shall be measured from the outside edge of the overhang.
7. Interpolation of (GC_P) between the two different h/B values is required for $0.5 < h/B < 0.8$.
8. B for Zone 3 is the l east horizontal dimension. B for Zones 1 and 2e is normal to the building width normal to the eave defining Zone 2e.

FIGURE 30.3-2F Components and Cladding [$h \le 60$ ft ($h \le 18.3$ m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Hip Roofs, 7°< θ ≤20° (Overhang)

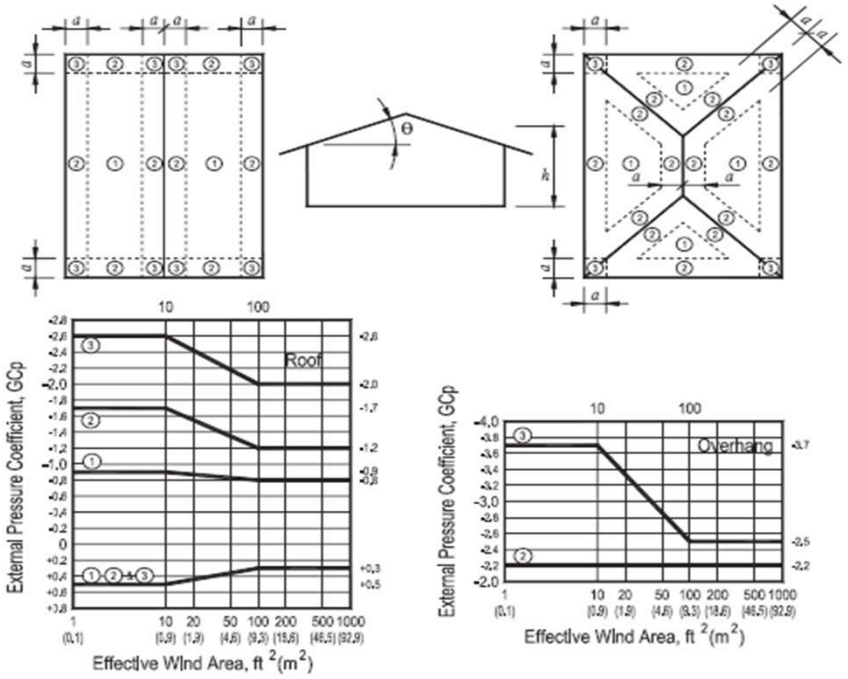
ASCE 7-16

ASCE 7-16 30 C & C - Hip Roofs (Low-Rise Analytical)

Components and Cladding | **h ≤ 60 ft.**

Figure 30.4-2B | **External Pressure Coefficients, GC_p**

Enclosed, Partially Enclosed Buildings | **Gable/Hip Roofs 7°< θ ≤ 27°**

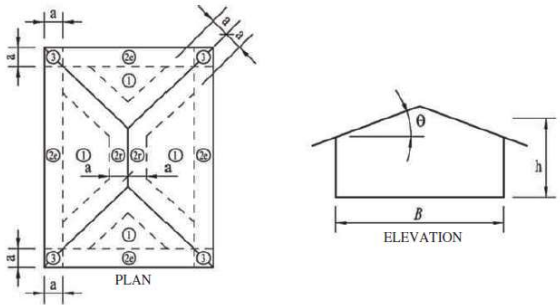


Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. Notation:
   - *a*: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - *h*: Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

ASCE 7-10

Diagrams



Notation

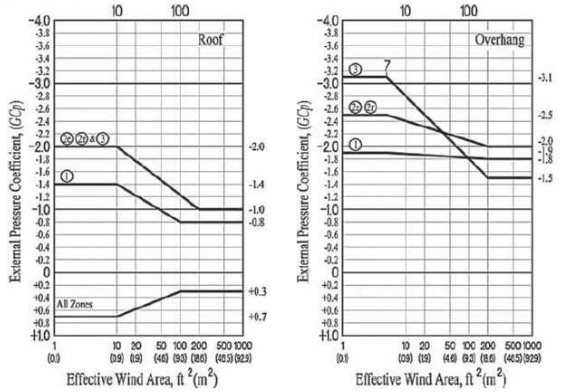
a = 10% of least horizontal dimension or 0.4*h*, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m). If an overhang exists, the edge distance shall be measured from the outside edge of the overhang. The horizontal dimensions used to compute the edge distance shall not include any overhang distances.

B = Horizontal dimension of building measured normal to wind direction, in ft (m).

h = Mean roof height, in ft (m).

θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients



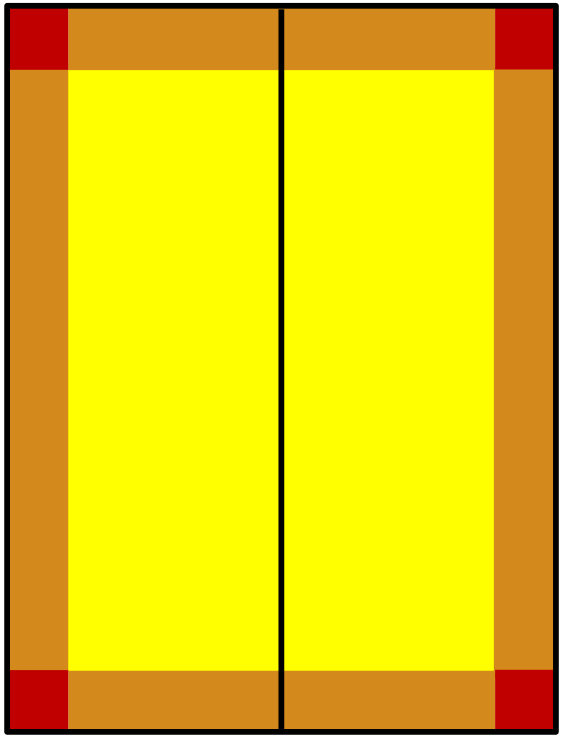
Notes

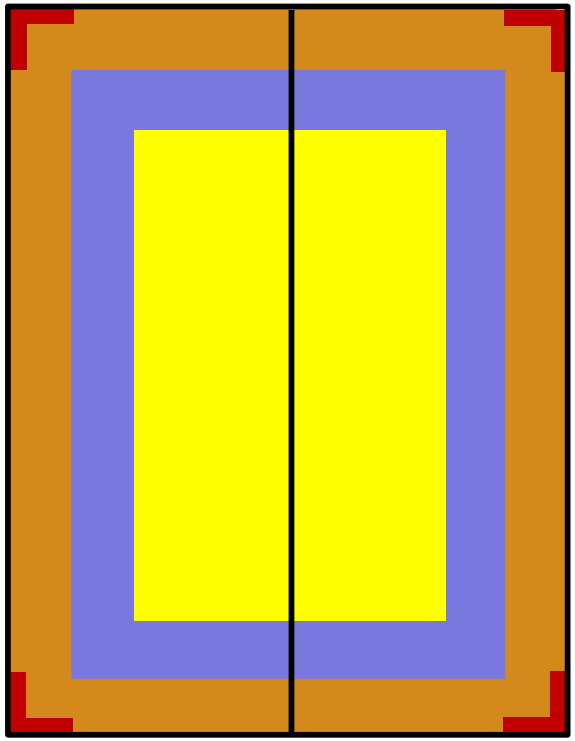
1. Vertical scale denotes (*GCp*) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of (*GCp*) for roof overhangs include pressure contributions from both upper and lower surfaces.
6. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, *a*, shall be measured from the outside edge of the overhang.

FIGURE 30.3-2G Components and Cladding [*h* ≤ 60 ft (*h* ≤ 18.3 m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Hip Roofs, 20° < θ ≤ 27° (Roof and Overhang)

ASCE 7-16

ASCE 7-10 Fig. 30.4-2A / ASCE 7-16 Fig. 30.3-2A
Gable Roof – h < 60 ft, θ ≤ 7°

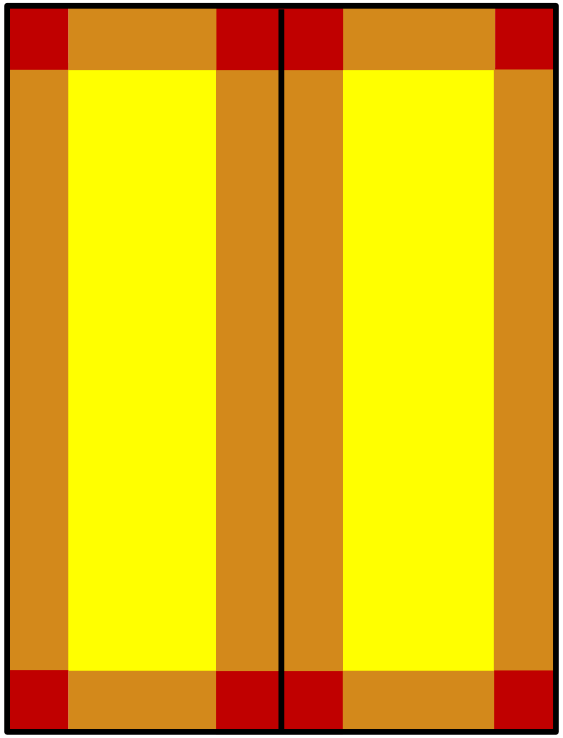


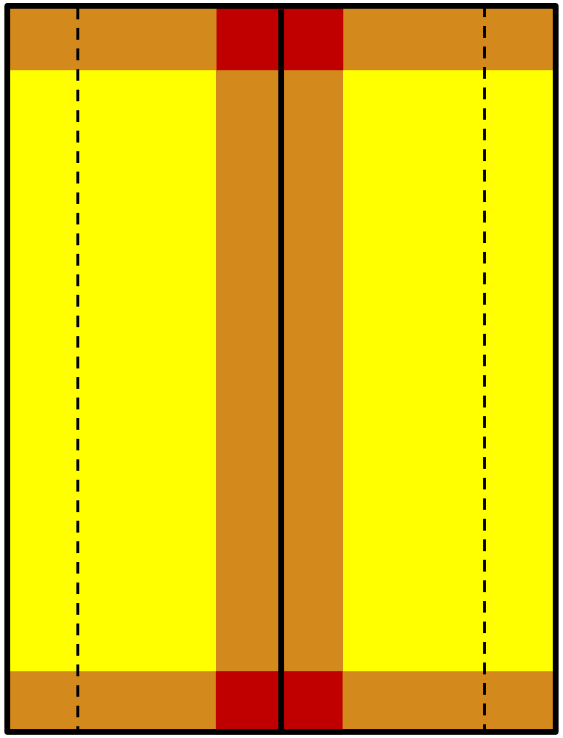


GC_P values for 10 ft^2 effective wind area

ASCE 7-10		ASCE 7-16	
	-2.8		-3.2
	-1.8		-2.3
	-1.0		-1.7
	-1.0		-0.9

ASCE 7-10 Fig. 30.4-2B / ASCE 7-16 Fig. 30.3-2B
Gable Roof – h < 60 ft, 7° < θ ≤ 20°

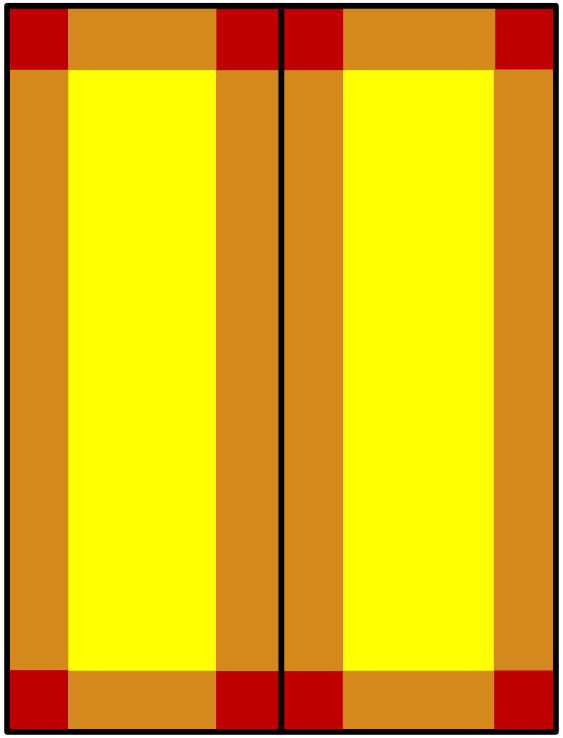


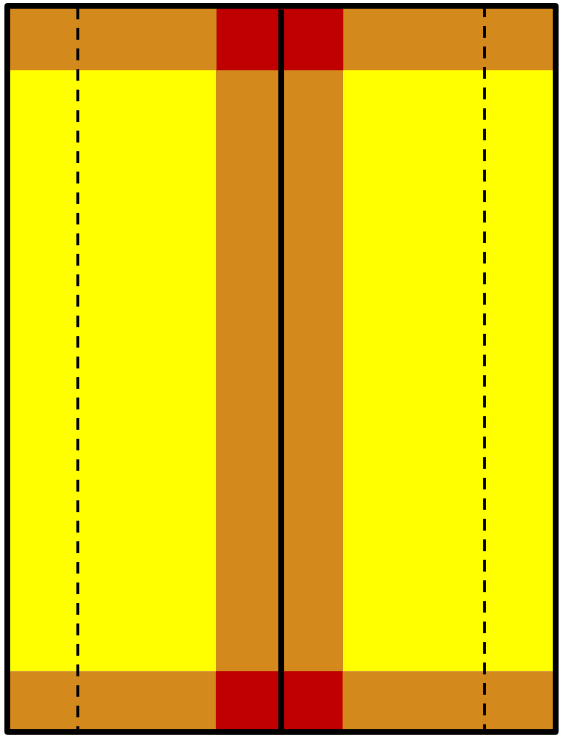


GC_P values for 10 ft^2 effective wind area

ASCE 7-10		ASCE 7-16	
	-2.6		-3.6
	-1.7		-3.0
	-0.9		-2.0

ASCE 7-10 Fig. 30.4-2B / ASCE 7-16 Fig. 30.3-2C
Gable Roof – h < 60 ft, 20° < θ ≤ 27°

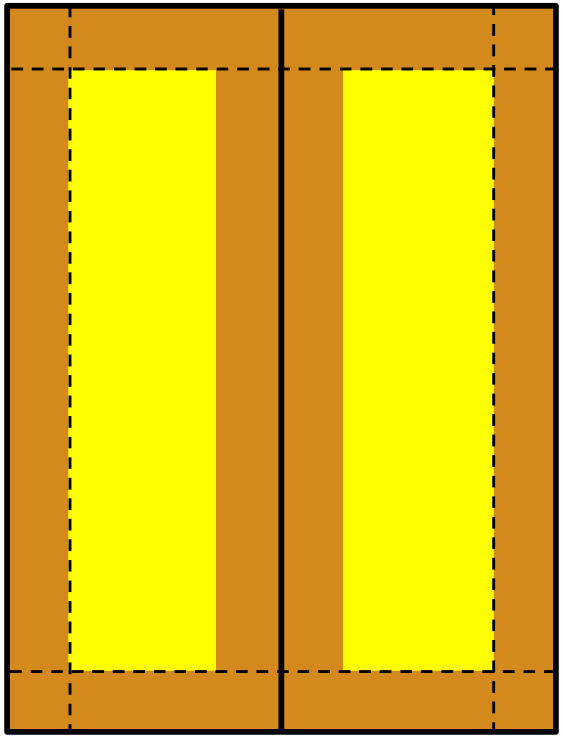


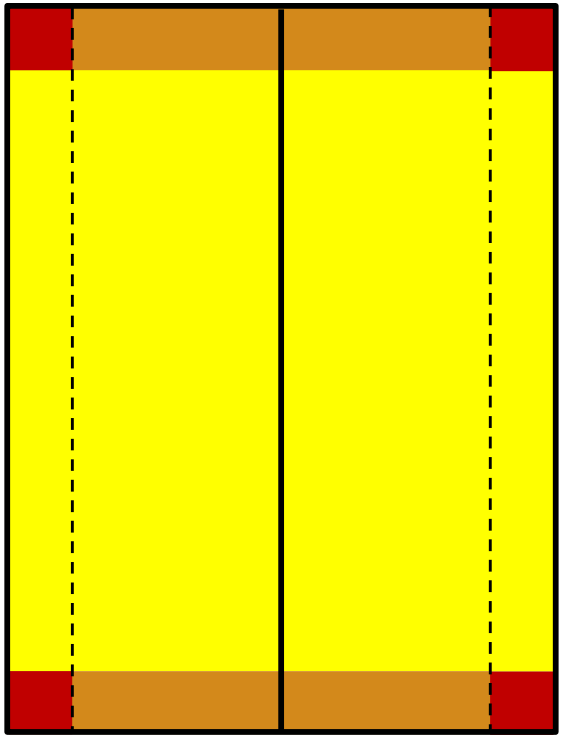


GC_P values for 10 ft^2 effective wind area

ASCE 7-10		ASCE 7-16	
	-2.6		-3.6
	-1.7		-2.5
	-0.9		-1.5

ASCE 7-10 Fig. 30.4-2C / ASCE 7-16 Fig. 30.3-2D
Gable Roof – h < 60 ft, 27° < θ ≤ 45°

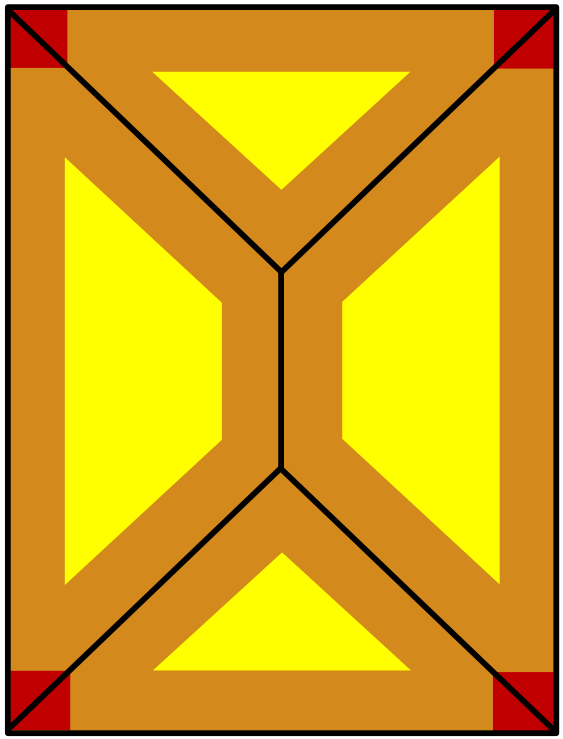


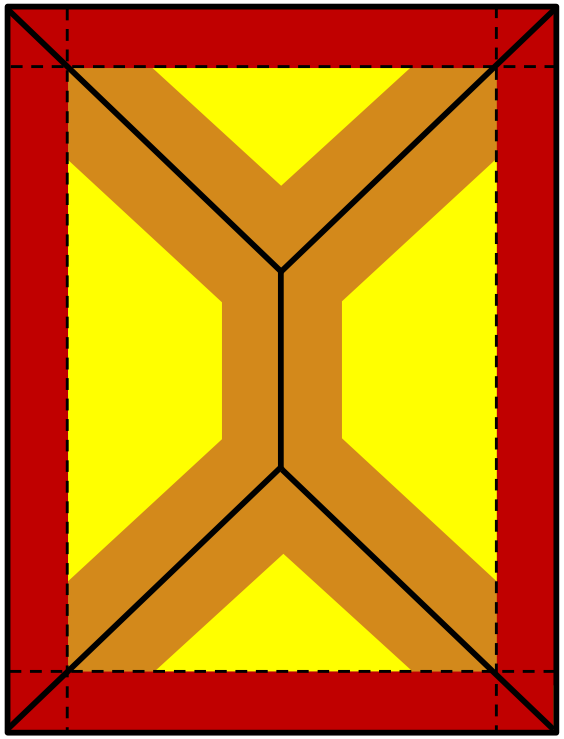


GC_P values for 10 ft^2 effective wind area

ASCE 7-10		ASCE 7-16	
	-1.2		-3.2
	-1.2		-2.0
	-1.0		-1.8

ASCE 7-10 Fig. 30.4-2B / ASCE 7-16 Fig. 30.3-2E
Hip Roof – h < 60 ft, 7° < θ ≤ 20°

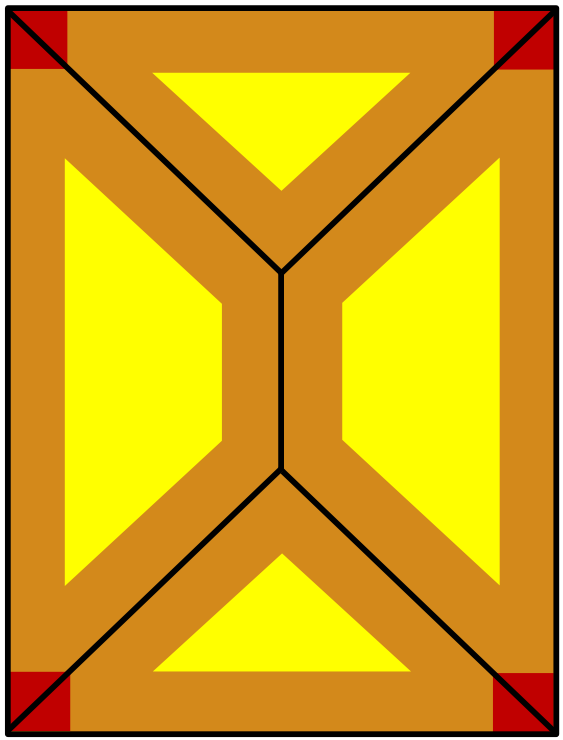


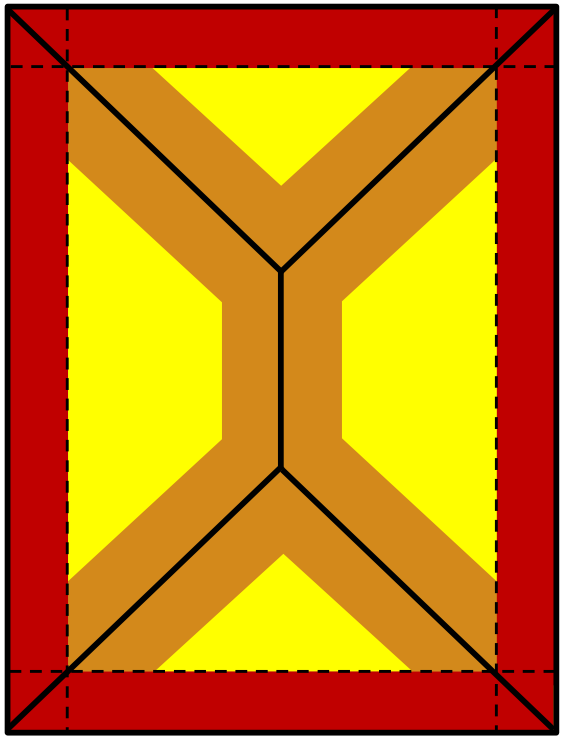


GC_P values for 10 ft^2 effective wind area

ASCE 7-10		ASCE 7-16		
			h/*B* ≥ 0.8	*h*/*B* ≤ 0.5
	-2.6		-2.6	-1.8
	-1.7		-2.4	-2.4
	-0.9		-1.8	-1.3

ASCE 7-10 Fig. 30.4-2B / ASCE 7-16 Fig. 30.3-2G
Hip Roof – h < 60 ft, 20° < θ ≤ 27°

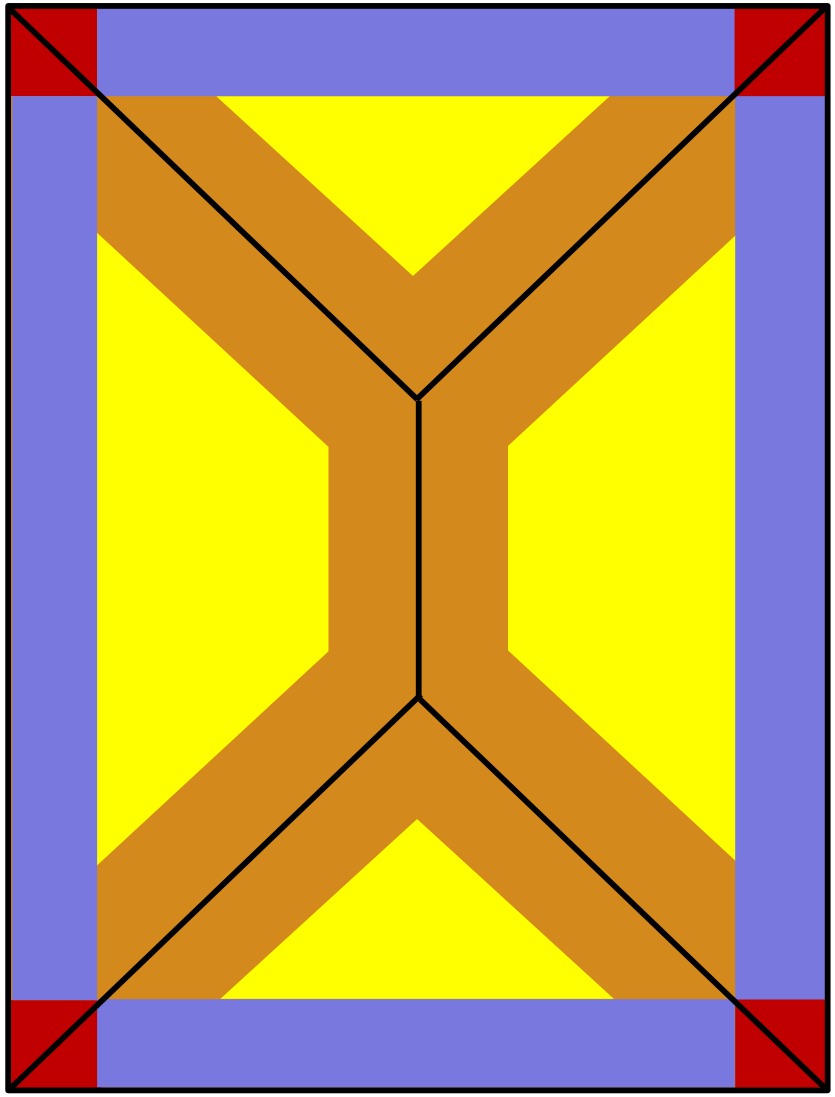




GC_P values for 10 ft^2 effective wind area

ASCE 7-10		ASCE 7-16	
	-2.6		-2.0
	-1.7		-2.0
	-0.9		-1.4

ASCE 7-16 Fig. 30.3-2H (New Figure)
Hip Roof – h < 60 ft, 27° < θ ≤ 45°



GC_P values for 10 ft^2 effective wind area and θ = 45°

ASCE 7-16	
	-2.50
	-2.35
	-1.80
	-1.50

Thank You!!

For more information…

www.skghoshassociates.com

Phone: (847) 991-2700
Email: kbhaumik@skghoshassociates.com

Follow us on:

File Attachments for Item:

EC-11 Firestop Plan Review and Inspection (Northwest Ohio Fire Prevention Association)

All certifications (8 hours)

John Hatzis

John Hatzis is the president of California Firestop Inspections LLC out of Sacramento California. He started his career as a volunteer Fire Fighter in Salisbury Township Pennsylvania and has moved over the years to a few departments performing functions from daily Fire Fighter duties, to Fire and Life Safety inspections and plan review. He worked as a Heavy Rescue Technician and was part of the relief effort at Ground Zero where he did rescue and recovery. John most recently worked in Morrisville Fire and Rescue in North Carolina before working for FedEx Ground doing facility Contracts and Inspections as part of Contractor Relations.

Seminar learning objectives

- • Understand how fire and smoke containment in construction is achieved
- • Know the code requirements for penetration and joint firestopping
- • Understand how firestopping materials are tested and to what standards
- • Understand why a system approach to firestopping is required
- • Be able to determine when the installation techniques meet applicable standards and code requirements

Seminar outline

- • What is firestopping, why is it required?
- • Code requirements (overview)
- • Through-Penetration firestop systems
- • Membrane penetration firestop systems
- • Fire resistant joint systems
- • Perimeter fire containment systems (edge-of-slab joints)
- • Duct enclosure systems
- • Firestop installation options
- • Engineering judgments
- • Special inspections and special inspectors
- • Recognizing firestop installation problems
- • Plan review and inspection process recommendations (Brief)
- • Notable changes in IBC 2009, 2012, 2015

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Thomas Miller

Organization: Northwest Ohio Fire Prevention Association

Address: 26100 Fort Meigs Rd, Perrysburg OH, 435551

E-mail: thomas.miller@com.ohio.gov Telephone: 614-623-3507

Website: www.nwofpa.org

Conference Sponsor (if applicable) _____ Conference Email: homas.miller@com.ohio.gov

Check here if Course Renewal: _____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Firestop Plan Review and Inspection

Course instructor: John Hatzis, President California Firestip Inspections LLC

Course description: Firestop Inspection and Plan Review

ICC Preferred Provider Course No. 10471, IFC Firestop 108

Instructional hours per session: 8 Number of Sessions: 1

Course Date(s) and Location: July 25, 26100 Fort Meigs Rd, Perrysburg, OH 43551

Special Content:

Code Administration: ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ☑
Administrative Course, All Certifications: ☑

Application materials included:

☑ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

INTERNATIONAL FIRESTOP COUNCIL
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Firestop Plan Review and Inspection

ICC PREFERRED EDUCATION PROVIDER

ICC Preferred Provider Course No. 10471
IFC Firestop 108 – Firestop inspection and plan review
0.7 CEUs

1

Please Sign In
AHJ Training Sign in Form (cognitoforms.com)

Copyright Materials

2

Presenters: please read

International Firestop Council
-PRESENTATION CODE OF ETHICS-

The Representative, when speaking about firestopping technology and using language, information, presentations, logos, or any other communication means that could be reasonably likely to cause the recipient(s) of such information to believe that the communication represents an official IFC technical viewpoint, shall:

- Hold themselves out to the public with professionalism and sound ethics by conducting themselves in a way that reflects positively on IFC and the IFC members
- Clearly state their affiliation
- Identify their relationship with IFC
- Declare that they are presenting an official (unmodified) presentation prepared by IFC
- Indicate whether the presentation is at the official request of IFC
- This presentation will not highlight, focus or reference to a specific product of manufacturer

3

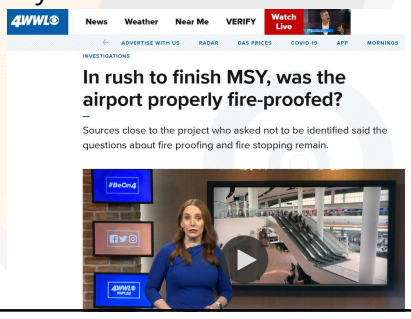
After the seminar....

- Please take our seminar feedback survey: https://www.surveymonkey.com/r/FirestopSeminar (only 3-4 mins!)

You can scan the QR code to take you to the survey

4

New Orleans airport expansion
A cautionary tale.....



5

Learning Objectives

1. Outline how fire containment in construction is achieved
2. List code requirements for firestopping
3. Explain how firestopping materials are tested and to what standards
4. Show why system approach to firestopping is required
5. Determine if installation techniques meet applicable standards and code requirements
6. Understand the 2012/15/18 IBC and NFPA 1 requirements for firestop Special Inspection

All International Building Code article numbers and text are from 2018 IBC unless otherwise noted

6

Seminar agenda

- **Overview of Fire Compartmentation**
- **Through Penetration Systems**
- **Membrane Penetrations**
- **Fire Resistive Joint Systems**
- **Perimeter Fire Barrier Systems**
- **Duct Enclosure Systems**
- **Understanding the Online Certification Directories**
- **Special Inspection**
- **Engineering Judgments**
- **Inspection Tips and Techniques**

7

Breaks

- Two in the morning
- Two in the afternoon
- Break durations: ~10 minutes
- Please take advantage of product samples and mock-ups (not to take away! ☺)

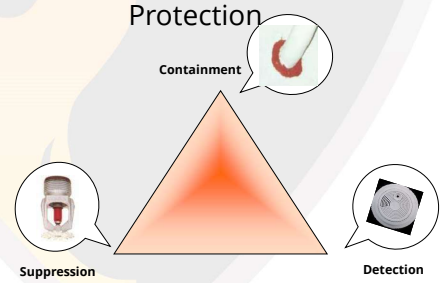
8

Let's get started….

- **Overview of Fire Compartmentation**
- Through Penetration Systems
- Membrane Penetrations
- Fire Resistive Joint Systems
- Perimeter Fire Barrier Systems
- Duct Enclosure Systems
- Understanding the UL Online Certifications Directory
- Special Inspection
- Engineering Judgments
- Inspection Tips and Techniques

9

Understanding Balanced Fire Protection



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IBC Balanced fire protection features

Require features that limit spread of fire and products of combustion:

- Sprinkler systems and other suppression systems (control)
- Fire rated horizontal assemblies and wall assemblies
- Smoke barriers
- Opening protection: rated doors, windows, shutters in rated assemblies
- Occupant egress requirements (e.g. dead ends, maximum distance to exit)
- Smoke management systems
- Fire detection and alarm systems
- Limitations on interior finishes and hazardous materials
- Limited heights and areas
- Structural protection

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Finding The Right Balance

Active Protection (Sprinklers and Alarms)

Passive Protection (Fire-resistive Assemblies)

12

Why is containment important?

Smoke & Toxic Gases

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Fire Statistics – Why We Must Contain Smoke and Toxic Gases

3/4 of all fire deaths are caused by smoke inhalation.

Source: Hall, Jr. John R. NFPA Fire Analysis & Research, Quincy, MA. "Burns, Toxic Gases, and other Hazards".

Visibility: 47% of survivors caught in a fire could not see more than **12 feet**

Source: NFPA Fire Protection Handbook, 18th Ed. Table 1-1P, Pg.1-15.

Approximately **57%** of **people killed** in fires are **not in the room** of the fire's origin

Source: NFPA Fire Protection Handbook, 18th Ed. Table 8-1P, Pg. 8-17.

Smoke travels **120-420 feet per minute** under fire conditions

Source: Estimate based upon ceiling jet velocity calculations for typical ceiling heights and heat release rates.

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Containment in Construction

- Fire-resistance-rated assemblies referenced in the IBC:
  - Fire Walls
  - Fire Barriers
  - Fire Partitions
  - Smoke Barriers
  - Horizontal Assemblies

Any gaps or discontinuities in those assemblies must also be fire-rated:

- Through and Membrane Penetrations
- Fire-resistant joint systems (i.e. construction joints and perimeter joints)
- Opening protection (i.e. fire-rated doors and windows)
- Air ducts and air transfer openings (i.e. dampers)

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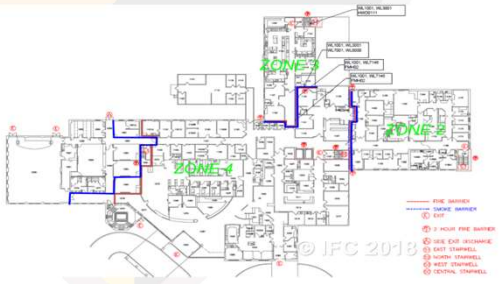
Fire Rated Compartments



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Critical Component of Containment

Firestopping

An assemblage consisting of a fire-resistance-rated floor, floor/ceiling, or wall assembly

+

One or more joints or penetrating items passing through assembly

+

Materials or devices, or both, installed to resist spread of fire through assembly for a prescribed period of time.

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Where it all began …

Browns Ferry Nuclear Power Plant
March 22, 1975

- the worst fire ever in commercial nuclear power plant operating in US
- fire spread along cable trays from the cable spreading room, through a cable penetration, and into the reactor building
- fire burned cables in cable trays for almost 7 hrs
- portable extinguishers used intermittently to no effect
- After almost 7 hrs, decision made to fight fire with water. Two men using fire hose extinguished fire within 15 mins
- UL was commissioned by US Nuclear Regulatory Commission (NRC) to develop penetration firestop test

Picture of TVA Browns Ferry seal penetration tests

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Large Loss Fires with Inadequate Containment

First Interstate Bank Building
Los Angeles, 1988

- Fire occurred on the 12th floor extending to 16th floor (62 story high-rise)
  - "The fire extended upward by…non-firestopped openings between the floor slab and the skin."
  - "The vertical spread was also through poke-through, pipe recesses, and utility shafts."
  - "The automatic sprinkler system was drained and building fire pumps shut off at time of fire."

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Large Loss Fires with Inadequate Containment

"The lack of firestopping between the floor slabs and the skin permitted the fire to spread from floor to floor through this space. Fire was observed spreading through this area even before the glass and mullions failed."

First Interstate Bank Building
Los Angeles, 1988

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One Meridian Plaza
Philadelphia – Feb. 23, 1991

- Fire destroyed 38-story office building
- Tenants sued owner
- Affected businesses within one block also sued
- Three Fire Fighters died, 24 injuries reported
- Claimed potential exposure: $800 million
- Building owner sued approx. 25 defendants
  - Including the general contractor, sub-contractors and manufacturers

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One Meridian Plaza
Philadelphia – Feb. 23, 1991

- Series of errors during fire
- Filler Type Foam used to "firestop" openings
- Fire spread quickly, knocking out power
- Water pressure inadequate for fire department hose streams
- Back-up generator failed

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One Meridian Plaza
Lawsuits galore!

- Building owner collected $110 million:
  - GC paid over $40 million
    - Claimed failure to supervise, install and inspect the fire protection system
  - Alarm manufacturer and servicer paid $10 million
    - Claimed inadequate alarm system
  - Back-up generator manufacturer
    - Claimed faulty wiring
  - Others settled out of court
- Burned-out building was downtown Philly eyesore until demolition in 1999

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Rockefeller Centre
New York, 1996

Fire occurred in the 5th floor electrical room:

- "Fire and smoke spread beyond the rooms involved due to a number of unprotected horizontal and vertical openings."
- "Based upon the NFPA's investigation and analysis of this fire, the following are considered significant contributing factors to the loss of property in this incident:
  - Unprotected vertical and horizontal penetrations. These openings allowed smoke to spread from beyond the electrical room and into the occupied areas."

Source: NFPA Fire Investigation Summary: "High Rise Fire Rockefeller Center"

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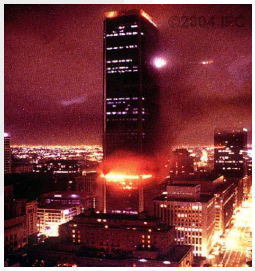
Why is Firestopping Required?

- Mandated by the Codes
- Life safety and property protection
- Provide time for first responders to perform their duties
- Containment



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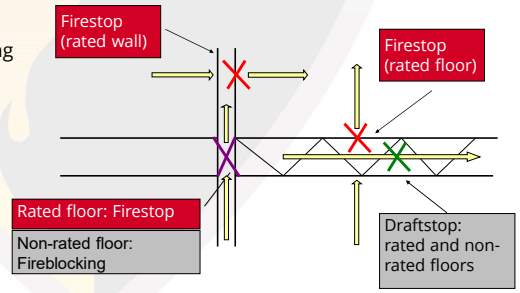
Do you know the difference?

- Firestopping
- Fireblocking
- Draftstopping



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Codes do not simply require "firestopping" Codes mandate *tested* (proven, rated) firestopping systems

"CLOSE ENOUGH IS NOT GOOD ENOUGH":
A Demonstration of Proper vs. Improper Firestopping

Click to go to YouTube

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IBC & NFPA 101 Referenced Fire Test Standards

Through Penetration	ASTM E814 UL 1479
Joints	UL 2079 ASTM E1966
Perimeter Barriers	ASTM E2307

ASTM: American Society of Testing and Materials

UL: Underwriters Laboratories Inc.

- Without some proof of testing to the relevant standard, any given firestop installation is not code-compliant

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Third Party Testing Labs

Underwriters Laboratories Inc.

FM Global (Factory Mutual)

Intertek Testing Services (ITS)

Southwest Research Institute

Labs Test to Standards

American Society of Testing and Materials (ASTM)

Underwriters Laboratories Inc. (UL)

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How does firestopping protect gaps created by burning/melting items?

- "Intumescent" firestop products will expand during heat of fire to fill gaps

Cast-in-place floor firestop device

Also:
View video at IFC YouTube channel

30

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How does firestopping protect gaps created by burning/melting items?

- "Intumescent" firestop products will expand during heat of fire to fill gaps

Electrical box insert

Also: View at IFC YouTube channel

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Firestop Plan Review and Inspection

- Overview of Fire Compartmentation
- **Through Penetration Systems**
  - **What is it?**
  - **Code Requirements**
  - **Fire Testing**
  - **Inspection**
- Membrane Penetrations
- Fire Resistive Joint Systems
- Perimeter Fire Barrier Systems
- Duct Enclosure Systems
- Understanding the Online Certification Directories
- Special Inspection
- Engineering Judgments
- Inspection Tips and Techniques

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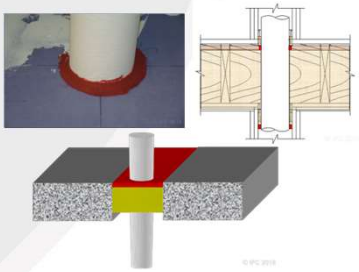
Penetration Firestop System

Consists of:

- Assembly being penetrated
- Penetrating item
- Fill, void or cavity materials (firestopping materials)



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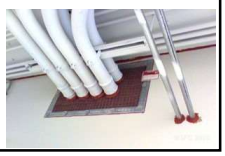
Wall Assemblies

714.4 Fire-resistance-rated walls

714.4.1.2 Through-penetration firestop system.
Through penetrations shall be protected by an approved penetration firestop system installed as tested in accordance with ASTM E814 or UL 1479, with a minimum positive pressure differential of 0.01 inch (2.49 Pa) of water and shall have an F rating of not less than the required fire-resistance rating of the wall penetrated.

➔ T-rating never required by code for wall through-penetrations



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Horizontal Assemblies

714.5 Horizontal Assemblies

714.5.1.2 Through-penetration firestop system.

Through penetrations shall be protected by an approved through-penetration firestop system installed and tested in accordance with ASTM E814 or UL 1479, with a minimum positive pressure differential of 0.01inch of water (2.49 Pa). The system shall have an F rating/T rating of not less than 1hour but not less than the required rating of the floor penetrated.

Exceptions to T-Rating only:
1. Floor penetrations contained and located within the cavity of a wall
2. Floor penetrations by floor drains, tub drains or shower drain located within the concealed space of a horizontal assembly
3. Max 4-inch diameter metal conduit or tubing penetrating directly into metal-enclosed electrical power switchgear.

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How to achieve T-rating

- Methods for achieving a T Rating = F-rating include:
  - Wrap metallic pipe with insulation above and/or below floor
    - mineral wool or ceramic insulation above and/or below floor
    - Glass fiber insulation only above floor
    - Proprietary, listed wrap materials (duct wrap, endothermic mats)
  - Small dia. penetrant in thick concrete floor
  - Listed systems provide details of what is needed

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Code Requirements: Smoke Barriers

- 714.5.4 – Penetrations in smoke barriers shall have an L- Rating at ambient and 400° F per UL2079
  - Max 5.0 CFM / sq ft of opening per penetration, or
  - Max cumulative leakage of 50 cfm for all penetrations within any 100 square feet of wall or floor area

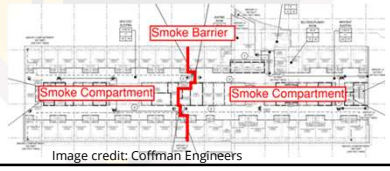

Image credit: Coffman Engineers

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Annular Space Requirements for automatic fire sprinkler piping in Seismic Areas

NFPA 13 – Installation of Sprinkler Systems

Annular Space requirements to prevent damage to sprinkler pipe

- If Pipe ≤ 3.5" then annular = 1"
- If pipe > 3.5" then annular = 2"
- "…the clearance shall be filled with a flexible material…"
- 2021 edition of NFPA 13 waives annular space for gypsum walls
  - Only IBC 2024 references NFPA 13-2021

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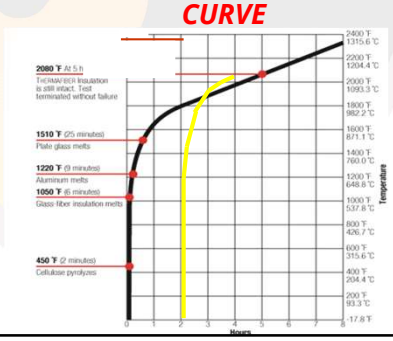
ASTM E119 TIME - TEMPERATURE CURVE



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Before

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During

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After

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Fire Test & Hose Stream Test

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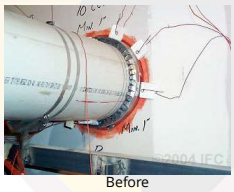
Example of Successful Testing

Construction - 4" PVC Through Drywall

Firestopping - Intumescent Device & Sealant



Before

After

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Ratings

- F-rating (pass/fail)
  - Passage of Flame
  - Hose Stream
- T-rating time is recorded/reported, not a pass/fail
  - Time at which temp rise >325°F on unexposed side
  - Code-mandated only for some floor penetrations
- L-rating: Air Leakage (Optional)
- W-rating: Water Leakage (Optional – never code mandated)

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Firestop inspection and plan review made easy

- Step 1: Ask the question:
  Show me (give me) the listed system used for every penetration firestop
- Step 2: Verification that the field condition meets the firestop system exactly
- There are 7500+ (!!) UL-listed through penetration firestop systems.
- Each is for very precise set of conditions

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Factors Affecting Penetrations

- Floor or wall construction type and thickness
- Size and shape of opening
- Size and type of penetrating item(s)
- Percent fill of cables
- Annular space
- Rating requirement
- Firestopping materials

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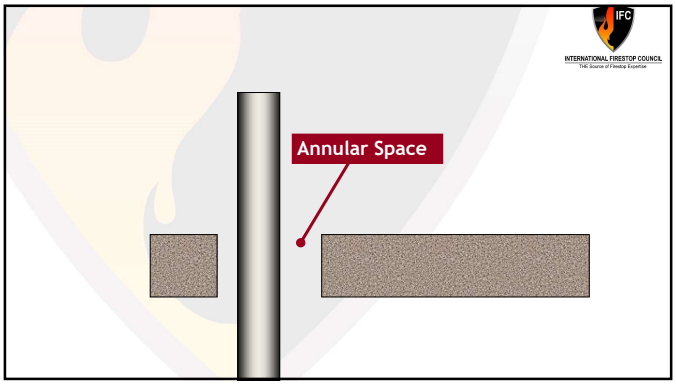

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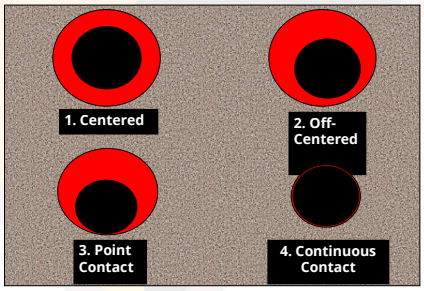
Typical Annular Space



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Sealant depth & location must be verified

5/8" specified in Listed System

< 5/8" installed in the field

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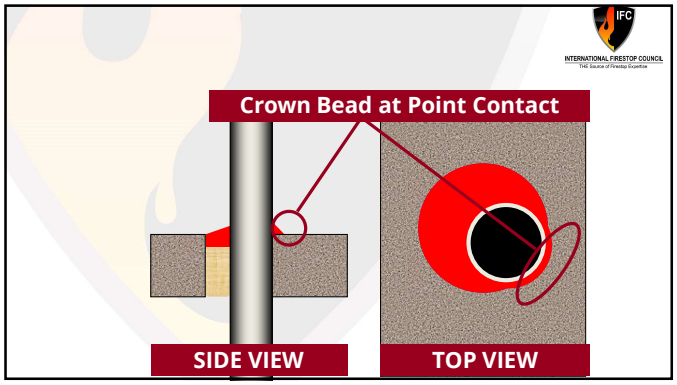

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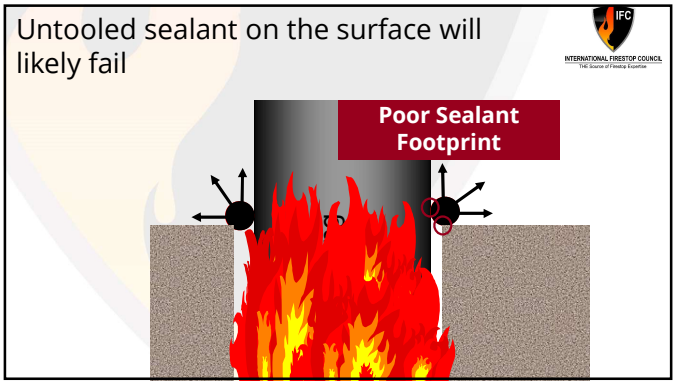
Untooled sealant on the surface will likely fail



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Properly Tooled Penetrations

- The Firestop sealant must be well bonded to penetrating item and surrounding wall or floor
- Should always inspect both sides

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Identifying a matching firestop system

- What type of building assembly is requiring firestopping?
  - Floor or Wall
- What type of material is the building assembly
  - Concrete, CMU, Gypsum, Wood Frame
- What is the penetrating item(s)?
  - Metallic, Nonmetallic, Cables, Insulated, Construction Joints, etc.
- What are the specific descriptions regarding the penetrants?
  - Diameter, quantity, type of plastic, type & thickness of insulation, etc.
- What is the hourly rating you are looking for?
  - F Rating, T Rating
- Are there any special considerations?
  - Movement, Environmental exposure

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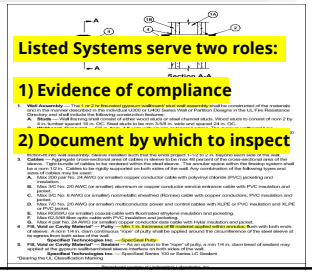
For Authority Having Jurisdiction (AHJ) (building/fire official) and Authorizing Authority (AA)



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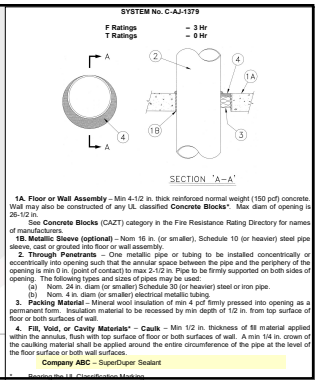
Verify chosen or installed system against field parameters

1. Type of wall or floor assembly, materials
2. Type of penetrating item (if any)
3. Opening size and type
4. Rating requirements (F-rating, T-ratings, etc.)
5. Any special considerations?



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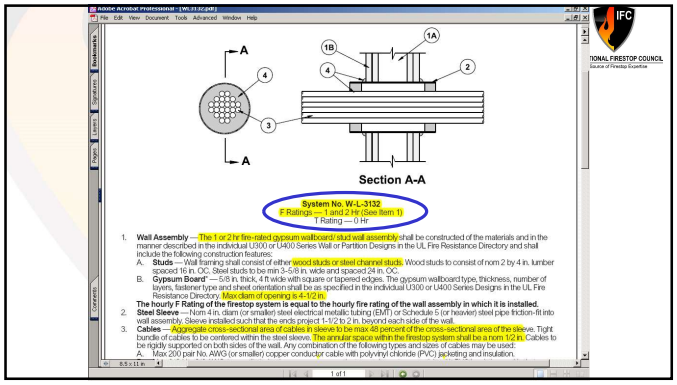

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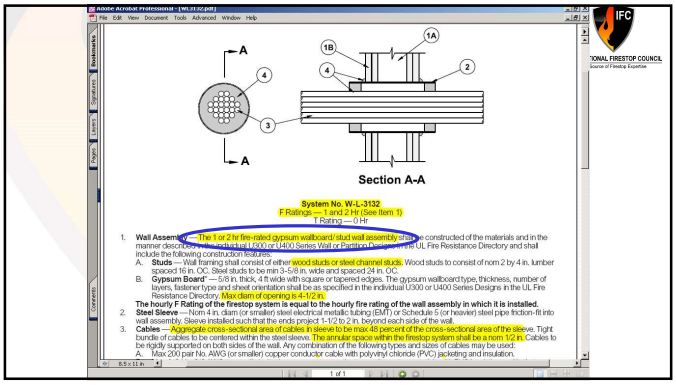

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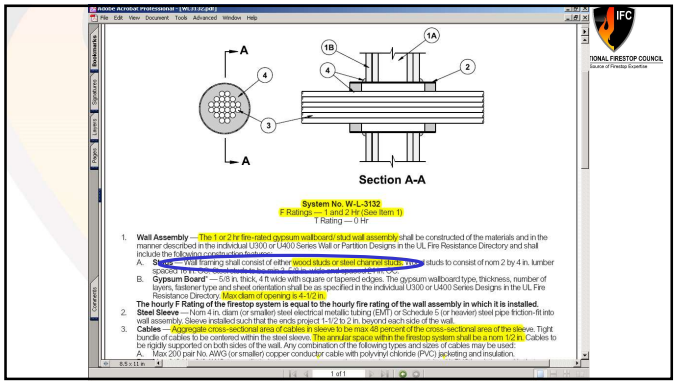

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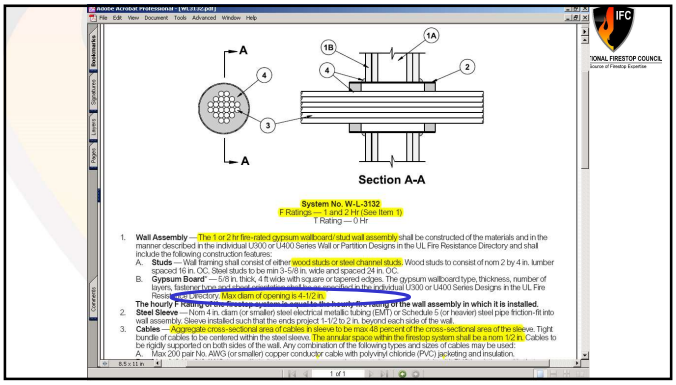

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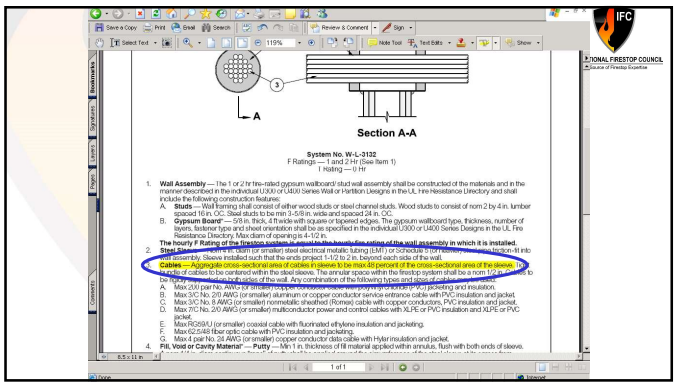

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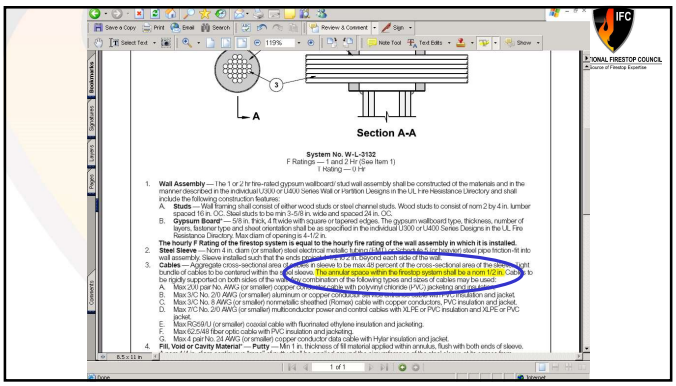

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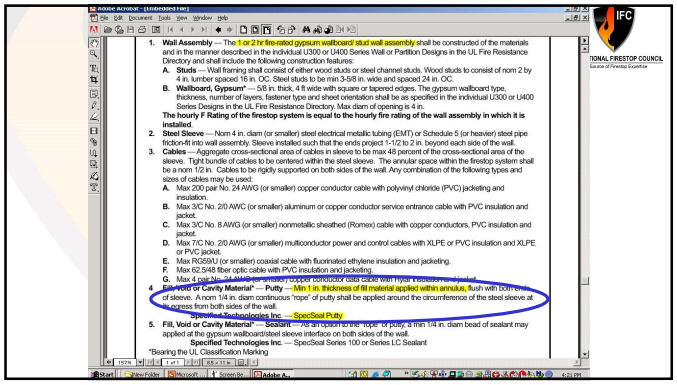

1. **Wall Assembly** — The 1 or 2 hr fire-rated gypsum wallboard/ stud wall assembly shall be constructed of the materials and in the manner described in the individual U300 or U400 Series Wall or Partition Designs in the UL Fire Resistance Directory and shall include the following construction features:
   - **A. Studs** — Wall framing shall consist of either wood studs or steel channel studs. Wood studs to consist of nom 2 by 4 in. lumber spaced 16 in. OC. Steel studs to be min 3-5/8 in. wide and spaced 24 in. OC.
   - **B. Wallboard, Gypsum*** — 5/8 in. thick, 4 ft wide with square or tapered edges. The gypsum wallboard type, thickness, number of layers, fastener type and sheet orientation shall be as specified in the individual U300 or U400 Series Designs in the UL Fire Resistance Directory. Max diam of opening is 4 in.

   The hourly F Rating of the firestop system is equal to the hourly fire rating of the wall assembly in which it is installed.
2. **Steel Sleeve** — Nom 4 in. diam (or smaller) steel electrical metallic tubing (EMT) or Schedule 5 (or heavier) steel pipe friction-fit into wall assembly. Sleeve installed such that the ends project 1-1/2 to 2 in. beyond each side of the wall.
3. **Cables** — Aggregate cross-sectional area of cables in sleeve to be max 48 percent of the cross-sectional area of the sleeve. Tight bundle of cables to be centered within the steel sleeve. The annular space within the firestop system shall be a nom 1/2 in. Cables to be rigidly supported on both sides of the wall. Any combination of the following types and sizes of cables may be used:
   - **A.** Max 200 pair No. 24 AWG (or smaller) copper conductor cable with polyvinyl chloride (PVC) jacketing and insulation.
   - **B.** Max 3/C No. 2/0 AWC (or smaller) aluminum or copper conductor service entrance cable with PVC insulation and jacket.
   - **C.** Max 3/C No. 8 AWG (or smaller) nonmetallic sheathed (Romex) cable with copper conductors, PVC insulation and jacket.
   - **D.** Max 7/C No. 2/0 AWG (or smaller) multiconductor power and control cables with XLPE or PVC insulation and XLPE or PVC jacket.
   - **E.** Max RG59/U (or smaller) coaxial cable with fluorinated ethylene insulation and jacketing.
   - **F.** Max 62.5/48 fiber optic cable with PVC insulation and jacketing.
   - **G.** Max 4 pair No. 24 AWG (or smaller) copper conductor data cable with Hylar insulation and jacket.
4. **Fill, Void or Cavity Material*** — **Putty** — Min 1 in. thickness of fill material applied within annulus, flush with both ends of sleeve. A nom 1/4 in. diam continuous "rope" of putty shall be applied around the circumference of the steel sleeve at its egress from both sides of the wall.
   Specified Technologies Inc. — SpecSeal Putty
5. **Fill, Void or Cavity Material*** — **Sealant** — As an option to the "rope" of putty, a min 1/4 in. diam bead of sealant may applied at the gypsum wallboard/steel sleeve interface on both sides of the wall.
   Specified Technologies Inc. — SpecSeal Series 100 or Series LC Sealant

*Bearing the UL Classification Marking

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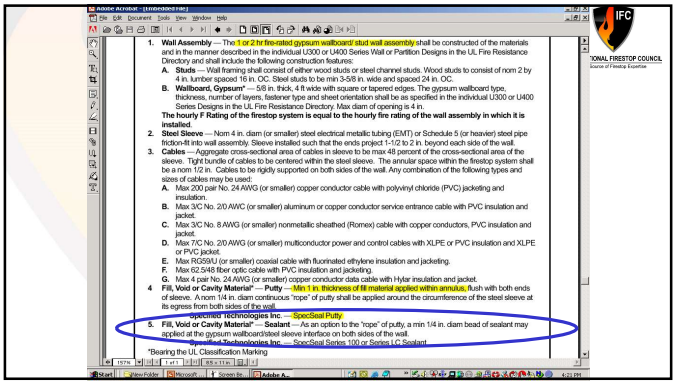

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*Bearing the UL Classification Marking

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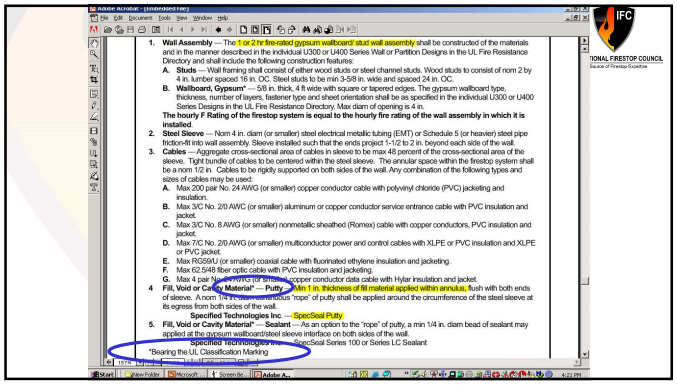

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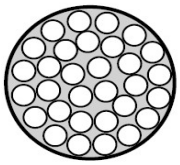
Fig. 2: Cable Loading...
Visually Full... Half Empty By Calculation!



Let's calculate the cable loading of this opening:
Diameter of Opening = 4"
Diameter of Cables = 5/8" (.625")
Number of Cables (N) = 21
Area of Opening (A) = πr^2 or 3.1416 x 2^2 = 12.57 sq. in.
Area of Cables (C) = πr^2 or 3.1416 x $.3125^2$ = .307 sq. in.
Cable Loading = $\frac{C \times N}{A} = \frac{.307 \times 21}{12.57} = 51\%$

- UL system listings for cables include "maximum % fill"
  - Some listings cite "visual" cable fill instead of actual

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Recap: Inspection of Penetrations

- Firestop system must be installed in accordance with all details of the tested and listed system
- Rating of the system must match the required rating of assembly being penetrated
- Penetrating item and opening size must match the tested and listed system

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Material Shrinkage

- Understand some sealants may shrink when installed
- Listing always reports wet sealant thickness
- ASTM C1241 shrinkage test
- % shrinkage, if available, is published by UL in manufacturer's listings summary page
  1. Go to UL Product iQ website (free registration)
  2. Type in "XHHW" into search box (listing category)
  3. Select the manufacturer whose product shrinkage data you need
  4. Scroll to very end of the webpage for ASTM C1241 data

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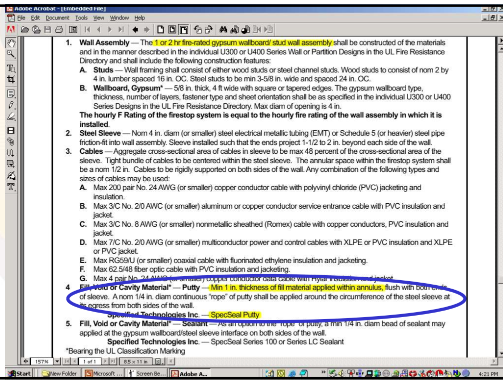

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  - **Code Requirements**
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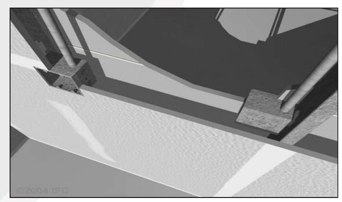
Electrical Membrane Penetrations

A breach in one side of a floor-ceiling, roof-ceiling, or wall assembly to accommodate an item installed into or passing through the breach.



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Firestop Code Requirements - IBC

Membrane Penetrations

- Sections 714.4.2: Membrane Penetrations
  Membrane Penetrations shall comply with Section 714.4.1*. Where walls or partitions are required to have a fire-resistance rating, recessed fixtures shall be installed such that the required fire-resistance will not be reduced.
  - Code Summary:
    - Membrane penetrations are firestopped at the wall membrane or surface, the same as through penetrations
- Metallic boxes installed per limits (exceptions) in IBC
- Nonmetallic boxes installed as tested and listed

* Penetration firestop system tested to E814/UL1479

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Metallic Electrical Outlet Box Allowances

Metallic boxes acceptable per code (without additional protection) if

- Maximum 16 sq in. outlet box, and
- Maximum 100 sq in. of opening on each side of wall per 100 sq ft of wall area, and
- Maximum 1/8 in. annular space between wall membrane and box, and
- Boxes on opposite sides of wall need to be either separated horizontally by minimum 24 in. or protected by some type of heat barrier

➔ Many installations will not meet all of the above

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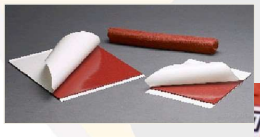
Metallic Electrical Outlet Box Exceptions

- Metallic boxes installed in up to 2 hr rated walls can
  - Exceed 16 sq in. outlet box
  - Exceed 100 sq in. of opening per 100 sq ft of ceiling area
  - Be closer than 24 in. on opposite sides of wall
- Provided such penetrating items are protected by listed putty pads or other listed materials and methods… and
- Installed in accordance with the listing

80

Firestop Putties

- Intumescent Putties
  - Hand moldable intumescent "putties



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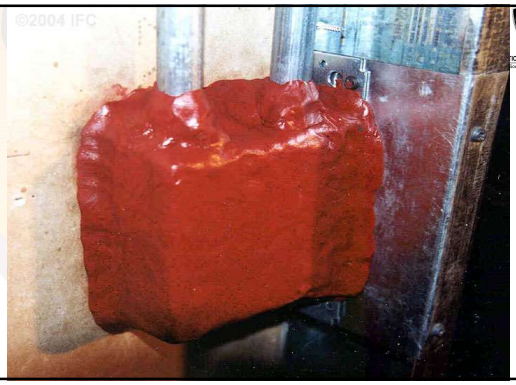
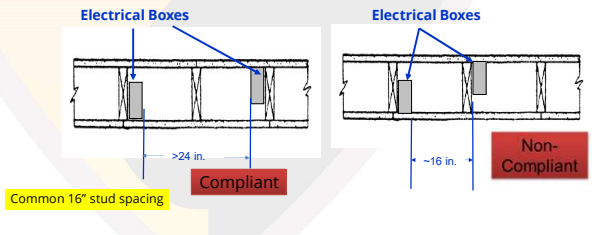


82

Metallic Electrical Boxes Opposite sides of wall Min 24 in. Spacing



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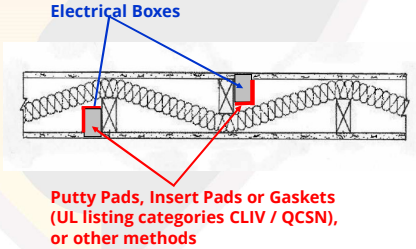
Metallic Electrical Boxes in Staggered Stud Walls

➔ Protection required regardless of spacing



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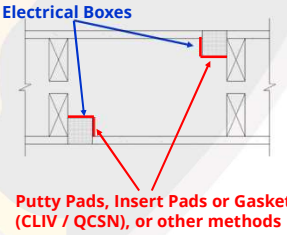
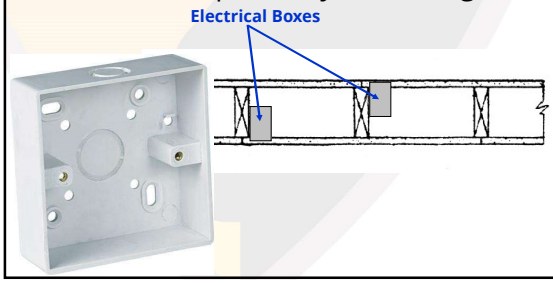
Metallic Electrical Boxes
Double Stud Walls
➔ Box protection required regardless of spacing



85

Nonmetallic Electrical box
Per fire rated box listing
or per Putty Pad listing



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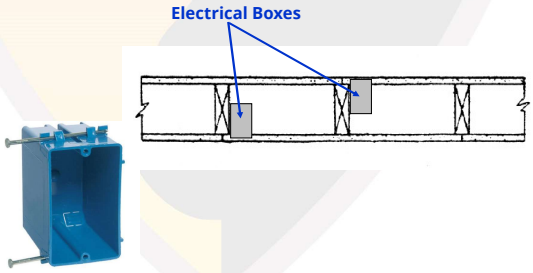
Listed Nonmetallic Electrical Spacing: per Listing



87

Misc Utility Boxes in fire-rated walls

- Other, non-electrical boxes **Permitted** when:
  - protected with a tested penetration firestop system, and
  - F & T rating equals required fire-resistance rating of wall penetrated, and
  - installed in accordance with their listing.
- Listed non-electrical boxes exist with inherent (listed) fire rating

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Metallic Electrical Outlet Boxes in Ceilings

- Metallic boxes acceptable per IBC:
  - Maximum 16 sq in. outlet box, and
  - Maximum 100 sq in. of opening per 100 sq ft of ceiling area, and
  - Maximum 1/8 in. annular space between ceiling membrane and box
- Installation not complying with these prescriptive requirements shall be protected by tested and listed solutions
  - UL "Wall opening protective materials" listing category (CLIV) does NOT apply to ceiling penetrations
  - no listed putty pad solutions for non-compliant ceiling boxes

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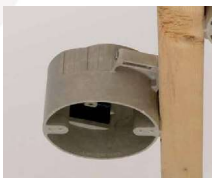
Nonmetallic Electrical Outlet Boxes in Ceilings

- Installed as tested and listed
- Maximum 1/8 in. annular space between ceiling membrane and box
- Listing mark must include "C" (for ceiling)



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Recessed fixtures in Ceilings

- Floor/ceiling assembly listings provide acceptable light fixtures and air transfer openings

91

Recap: 5 possible challenges

- Boxes on opposite sides of wall too close (24" rule)
- Boxes in communicating stud cavity

- Boxes too big (> 16 sq. in.)
- Too many boxes in one small area (> 100 sq. in. per 100 sq ft of wall)
- Non-metallic outlet boxes
- See IFC "**Guide for Protection of Recessed Boxes in Fire-rated Walls Using Firestop Putty Pads, Box Inserts, Cover Plate Gaskets and Endothermic Mats** " (7 pages)

www.firestop.org/technical-library

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IBC - Definition

IBC Definition of JOINT

- The opening in or between adjacent assemblies that is created due to building tolerances or is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.

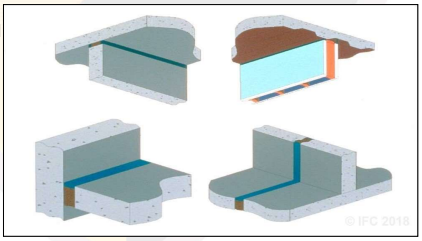
95

Fire rated Joint System Parameters

- Nominal Joint Width
- Assembly Rating
- Movement
- Extension
- Compression
- Percent (%) Extension / Compression
- Mineral Wool Compression
- Sealant Depth

96

Types of joint systems
Juncture of two fire-rated assemblies



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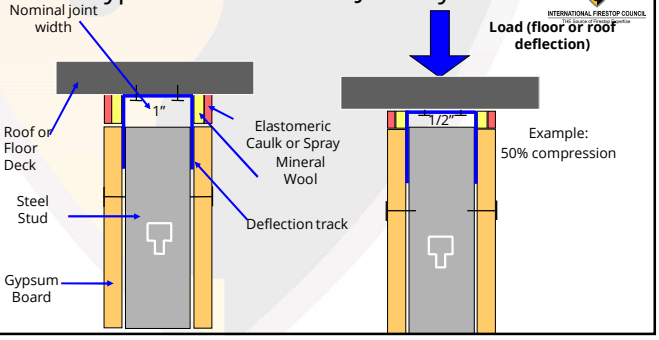
Categories of Fire-Resistive Joint systems

- Sealant Systems (Caulks)
- Sprayed /Elastomeric Membranes (Sprays)
- Mechanical Joints
- Pre-formed joint systems

98

Typical Head of Wall Joint System



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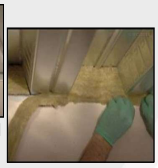
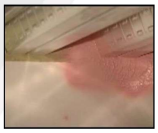
Head-of-Wall Spray Application

Flutes are packed with mineral wool per listed system.



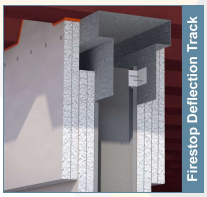
Remaining joint is packed with mineral wool per listed system.

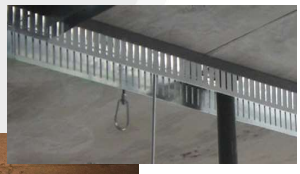


Firestop sealant is applied to both sides of wall per listed system.

100

Mechanical top-of-wall Joint Systems





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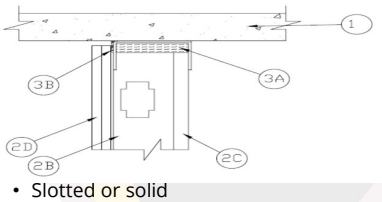
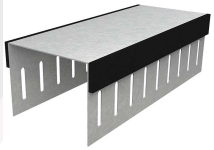
Factory Applied Intumescent on Track





- Slotted or solid
- Gap remains unfilled
- 3A = mineral wool inside top track (shaft wall only)
- 3B = factory applied intumescent on top or side of track
- Intumescent on top visible from side view

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Framing devices with intumescent tape

- Post-installed
  - after wall framing, prior to drywall
- Must be installed on both sides

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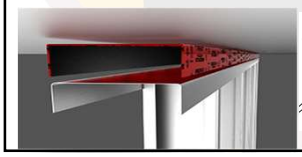
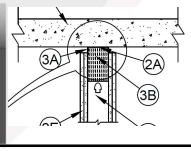
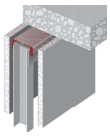
U-shaped firestop gasket

- Installed during ceiling runner installation
- Sides must drape down – cover vertical leg
- Side legs can't be penetrated by screws
- For profiled decks, mineral wool is needed in flutes
- Some systems require mineral wool within track







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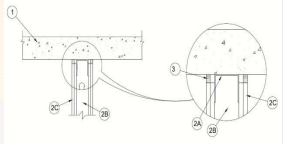
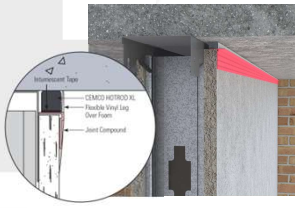
Compressible Foam Gasket



- Only for flat concrete
- 2-hr system may not fill full depth
- Some gasket compression required
- Installed after drywall
- Both sides of wall
- Must verify proper orientation

105

Post-installed preformed joint systems



- Specialty firestop tape used over mineral wool instead of spray or sealant
- Foam gasket factory-applied to vinyl trim

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Floor-to-floor building expansion joints (Typically large)

- Must support full live loads
  - "Stuff and spray or caulk" joint systems used for small joints not applicable

Examples:

107

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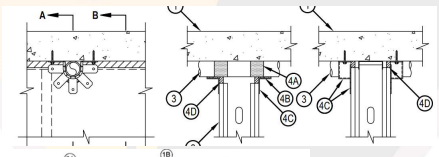
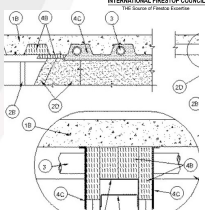
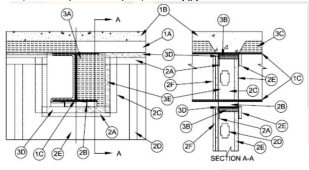
Penetrations through joints



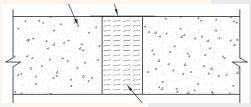




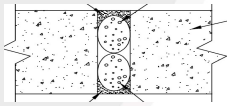
- Some head-of-wall joint systems allow for penetrations
- Beam penetrations are part of some listed joint systems

108

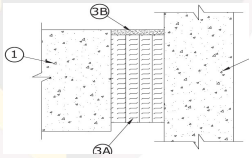
Other Typical Joint Systems



• Floor to Floor



• Wall to Wall



• Floor to Wall

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Firestop Plan Review and Inspection

- Overview of Fire Compartmentation
- Through Penetration Systems
- Membrane Penetrations
- **Fire Resistive Joint Systems**
  - What is it?
  - **Code Requirements**
  - Fire Testing
  - Inspection
- Perimeter Fire Barrier Systems
- Duct Enclosure Systems
- Understanding the UL Online Certifications Directory
- Special Inspection
- Engineering Judgments
- Inspection Tips and Techniques

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Building Code Requirements Fire Resistive Joints

Section 715.1: Fire Resistive Joint Systems

"Joints installed in or between fire-resistance rated walls, floor or floor/ceiling assemblies and roofs or roof/ceiling assemblies shall be protected by an approved fire-resistant joint system designed to resist the passage of fire for a time period not less than the required fire-resistance rating of the wall, floor or roof in or between which the system is Installed."

Exceptions: 9 specific exemptions exist
e.g. walls permitted to have unprotected openings, floors within malls, etc..

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Building Code requirements Fire Resistive Joints – 715.1 Exceptions

Fire resistive joint systems not required in the following:

Floors
- Within single dwelling unit
- Where joint is protected by shaft enclosure
- Within atriums
- Within malls
- Within parking garages
- Mezzanines

Other locations
- Walls permitted to have unprotected openings
- Roofs where openings are permitted (i.e. almost all roofs)
- Max. 5/8 in wide controls joints if tested as part of assembly in accordance with ASTM E119/UL 263

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Building Code Requirements IBC – Joints

- 715.2 Installation- A fire-resistant joint system shall be securely installed in accordance with the manufacturer's installation instructions and the listing criteria in or on the joint for its entire length so as not to impair its ability to accommodate expected building movements and to resist the passage of fire and hot gases.
- 715.3 – Fire-resistant joint systems shall be tested to ASTM E 1966 or UL 1479

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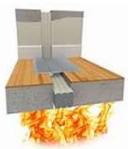
Building Code Requirements IBC – Joints in Smoke Barriers

- Must be designed and constructed to restrict the movement of smoke.
- Rating used: L Rating
  - measurement of air leakage rate through a fire resistive joint system or penetration.
- 715.6 - Joints in smoke barriers shall have an L Rating not in excess of 5 cfm / lineal ft of opening



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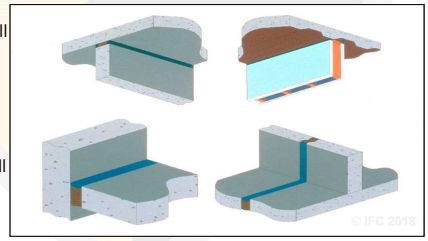
Fire Resistive Joint Testing

Head of Wall (Flat Deck)

Head of Wall (Fluted Deck)



Floor to Wall

Floor to Floor and Wall to Wall

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Fire Resistive Joint Testing

Head of Wall Joint

Floor to Floor Joint

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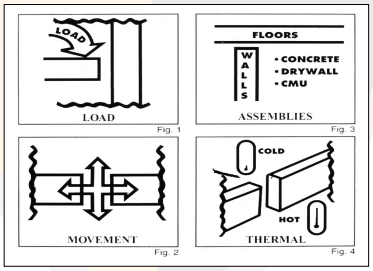
Forces Which Induce Movement



- Live load
- Thermal
- Seismic

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Cycling of joint prior to fire test per ASTM E1399:

Cycling Requirements

Class Movement	Min. Cycles	Frequency
I	500	1 cycle / min.
II	500	10 cycle / min.
III	100	30 cycle / min.
IV	100	30 cycle/min and
	400	10 cycle / min.

- Cycling conducted prior to fire test
- Joint fire tested at maximum extension
- Listing will report maximum extension and compression
  - Beware systems with compression only – no such real life applications!

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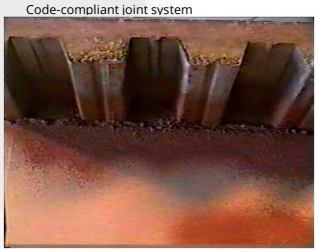
Joints with/without successful joint cycling test

Non-code-compliant joint seal

Code-compliant joint system

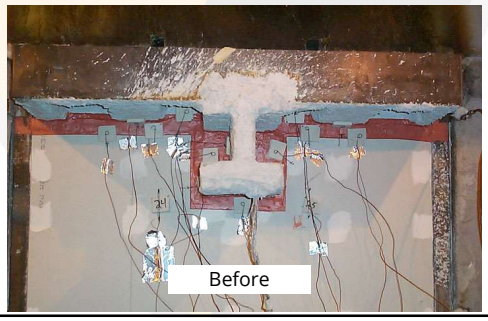


Almost all construction joints will be dynamic

Videos courtesy of Hilti

120

Head of Wall Joint Test per ASTM 1966 / UL 2079



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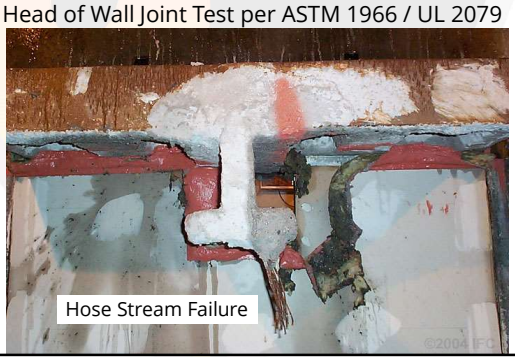
Head of Wall Joint Test per ASTM 1966 / UL 2079

122

Head of Wall Joint Test per ASTM 1966 / UL 2079

123

Head of Wall Joint Test per ASTM 1966 / UL 2079



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Firestop inspection and plan review made easy

- Step 1: Ask the question:
  Show me (give me) the listed system used for every joint type in/between fire-rated walls or floors
- Step 2: Verification that the field condition meets the firestop system exactly

- There are 2300+ (!!) UL-listed fire resistive joint systems.
- Each is for very precise set of conditions

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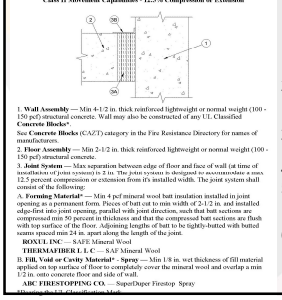
Compare system and field conditions



System No. FW-D-0001

Assembly Rating - 1 Hr
1. Rating at Ambient — Less than 1 CFM/Lin Ft
1. Rating at 400 F — Less than 1 CFM/Lin Ft
Nominal Joint Width - 2 In.
Class II Movement Capabilities - 12.5% Compression or Extension

1. **Wall Assembly** — Min 4-1/2 in. thick reinforced lightweight or normal weight (100 - 150 pcf) structural concrete. Wall may also be constructed of any UL Classified **Concrete Blocks***.
See **Concrete Blocks** (CAZT) category in the Fire Resistance Directory for names of manufacturers.
2. **Floor Assembly** — Min 2-1/2 in. thick reinforced lightweight or normal weight (100 - 150 pcf) structural concrete.
3. **Joint System** — Max separation between edge of floor and face of wall (at time of installation of joint system) is 2 in. The joint system is designed to accommodate a max. 12.5 percent compression or extension from it's installed width. The joint system shall consist of the following:
A. **Forming Material*** — Min 4 pcf mineral wool batt insulation installed in joint opening as a permanent form. Pieces of batt cut to min width of 2-1/2 in. and installed edge-first into joint opening, parallel with joint direction, such that batt sections are compressed min 50 percent in thickness and that the compressed batt sections are flush with top surface of the floor. Adjoining lengths of batt to be tightly-butted with butted seams spaced min 24 in. apart along the length of the joint.
ROXUL INC — SAFE Mineral Wool
THERMAFIBER LLC — SAF Mineral Wool
B. **Fill, Void or Cavity Material* - Spray** — Min 1/8 in. wet thickness of fill material applied on top surface of floor to completely cover the mineral wool and overlap a min 1/2 in. onto concrete floor and side of wall.
ABC FIRESTOPPING CO. — SuperDuper Firestop Spray

1. What type of building assemblies form the joint?
   - Floor/Floor, Floor/Wall, Wall/Wall, Top of Wall/Ceiling
2. What materials are the assemblies constructed from?
   - Concrete, CMU, Gypsum
3. What is the required hourly rating?
   - Assembly rating (1 – 4 hour)
4. What is the width of the joint (inches)?
5. How much movement is required?
   - Must accommodate building movement (% of joint size)
6. Are there any special considerations?
   - Unique construction condition, environmental exposure

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Does the submitted joint system seem correct?

Reading UL Nomenclature for Joint Systems

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UL Nomenclature

Navigating the UL Directory: **HW – D – 0060**

JOINT SYSTEMS (XHBN)

First Two Alpha Characters identify the type of joint system:

FF	=	Floor-to-Floor
WW	=	Wall-to-Wall
FW	=	Floor-to-Wall
HW	=	Head-of-Wall

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UL Nomenclature Cont.

Navigating the UL Directory: **HW – D – 0060**

JOINT SYSTEMS (XHBN)

Third Alpha Character identifies the movement capabilities of the system:

D = Dynamic (movement capabilities)
S = Static (no movement capabilities)

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UL Nomenclature Cont.

Navigating the UL Directory: **HW – D – 0060**

JOINT SYSTEMS (XHBN)

First Numeric Character identifies the nominal width of the linear opening:

0000 – 0999	= ≤ 2 in.
1000 – 1999	= > 2 in. and ≤ 6 in.
2000 – 2999	= > 6 in. and ≤ 12 in.
3000 – 3999	= > 12 in. and ≤ 24 in.
4000 – 4999	= > 24 in.

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UL Nomenclature Cont.

Navigating the UL Directory: **HW – D – 0060**

JOINT SYSTEMS (XHBN)

Second Through Fourth Numeric Characters identify the individual system number

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Common Joint System Correction Notices

- "Deflection is required to be installed with an approved joint system per Section 715 of the IBC. The assemblies need to be designed to allow joints to compress and extend with movement of structure while maintaining the fire-rating of the assemblies."
- "Please clarify building deflection by listing the Maximum and Minimum building deflection movements to determine movement capabilities of assembly and identify listed assemblies for all joint systems."

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Field Inspection of Joint Systems

- Identify the type of building assemblies that form the joint (e.g. type, thickness)
- Verify the materials and installation of the joint system
- Are there any special considerations?
  - Conditions that require Engineering Judgments (not within listed system parameters)
  - High movement requirements

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What to Look For

- Ensure the framing members allow for required movement
- Confirm appropriate backing material is used if required
  - Mineral wool may be used above the track or inside top track
  - Manufacturer and type (eg. Type SAF and SAFE)
  - Nominal density (typically 4pcf if field cut. 6pcf for prefab)
  - Compression and orientation per listing

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Joint Inspection Process

- Inspect joint systems during framing inspection
- Contractor to provide you with the listed assembly as shown / approved on the plans
- Confirm all joint systems will accommodate required movement
- For Mechanical Joints observe the ceiling runner for the label located on the side of the runner

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Joint Systems - Summary

- Provide tested and listed systems that includes joint movement at Plan Review or before field inspection
- Joints must accommodate expected building movement
- Inspect some joint systems during framing inspection

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Firestop Plan Review and Inspection

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What is a Curtain Wall?

An exterior building wall which carries no roof or floor loads and consists of metal, glass or stone or any combination thereof supported by a metal frame.

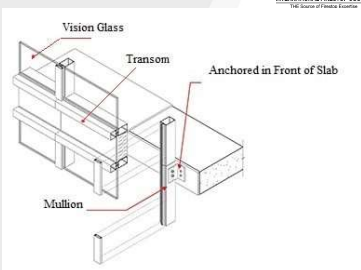

Image credit: Theconstructor.org

140

Unprotected perimeter joints or improperly installed perimeter fire containment systems cost lives and huge liability losses…

- Summerland, Isle of Man, British Isles. Fire spread through safing joint. 50 people killed.
- Hilton Hotel, Las Vegas, NV. Fire spread from 8th to 13th floor in 25 minutes. 8 fatalities.
- First Interstate Bank, Los Angeles, CA. Flames spread from 13th to 16th floor via perimeter joint. One death.
- One Meridian Plaza, Philadelphia, PA. Fire spread from 22nd to 30th floor through unprotected openings including slab edge.

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Perimeter Fire Containment Systems

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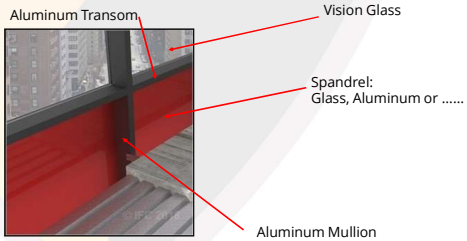
Common Terminology



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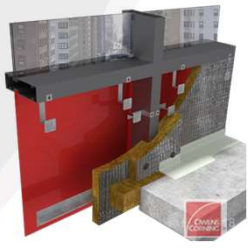
Curtain Wall Fire Containment Six Basic Design Principles

1. **Reinforcement Member**
2. **Mineral Wool Spandrel Insulation** (ASTM E2307 approved)
3. **Mechanically Attached MW Spandrel Insulation**
4. **Compression Fit MW Safing** (ASTM E2307 approved)
5. **Protect Vertical Mullions**
6. **Smoke Barrier** (ASTM E2307 approved)



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Typical Curtain Wall System Cont.

Mechanical attachments are used to hold the curtain wall insulation (not shown) in place and are attached to the curtainwall framing. These come in many forms such as hangers, stick pins, steel angles, as well as other forms.

- Design Listings outlines required method of attachment

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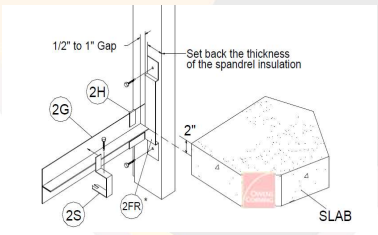
Typical Curtain Wall System Cont.



Reinforcement member or backer bar set 2" below top of slab to support curtain wall insulation from bowing due to compression of Safing insulation. Can be a T-bar, hat channel, steel angle, as well as others. Must be mechanically attached to mullions.

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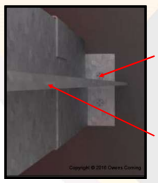
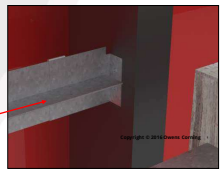
Typical Curtain Wall System Cont.

Reinforcement member or backer bar



Mechanically Attached (screw)

Reinforcement Member



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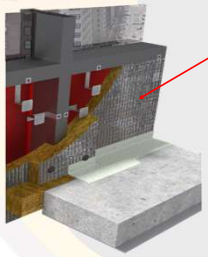
Typical Curtain Wall System Cont.



Minimum 2 in. thick, nom. 8 pcf density mineral wool spandrel insulation (ASTM E2307 compliant) faced on one side with aluminum foil scrim. Curtain wall insulation tightly fitted between framing members and mechanically attached to mullions and transoms.

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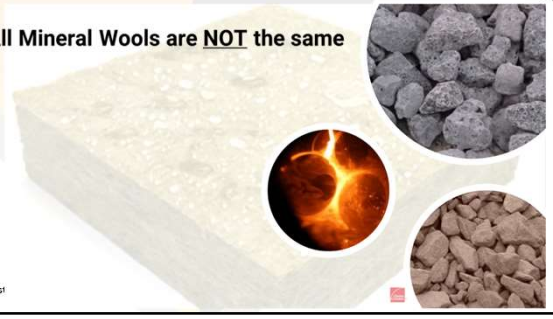
ASTM E2307 Tested Mineral Wool

All Mineral Wools are NOT the same



Firest

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ASTM E2307 Tested Mineral Wool

- Non Combustible
- Thermal Performance
- Sound Control
- Moisture Performance

Firestop Plan Review and Inspection

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ASTM E2307 Tested Mineral Wool

3rd Party Certification of Products & Systems

Firestop Plan Review and Inspection 151

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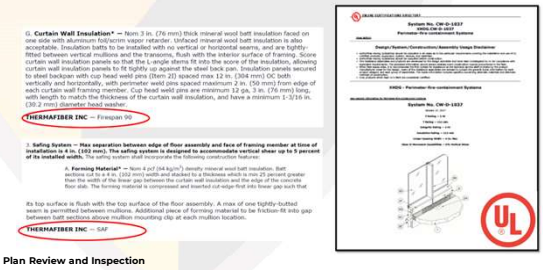
ASTM E2307 Tested Mineral Wool

All Mineral Wools are NOT the same



Firestop Plan Review and Inspection 152

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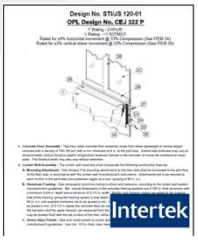
ASTM E2307 Tested Mineral Wool

All Mineral Wools are NOT the same



Firestop Plan Review and Inspection 153

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ASTM E2307 Tested Mineral Wool

All Mineral Wools are NOT the same

Firestop Plan Review and Inspection 154

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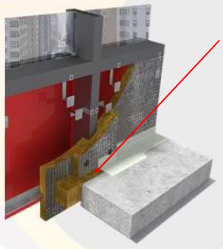
Typical Curtain Wall System Cont.



4 in. thick, 4 pcf density ASTM E2307 tested mineral wool installed with the fibers orientated vertically. Mineral wool to be properly compressed per listed system in the thickness dimension, and installed flush with the top of the floor slab.

Example. An 8 in. joint requires 10-2/3" of mineral wool safing within the joint. (25% compression)

$T_{uncomp} = (W_{nom} \times 100) / (100 - I_{comp})$
$= (8 \times 100) / (100 - 25)$
$= 800/75 = 10.67$

T_{uncomp} = Uncompressed Thickness Necessary, in.
I_{comp} = Insulation Compression Percentage Specified in System, percent
W_{nom} = Nominal (Installed) Joint Width, in.

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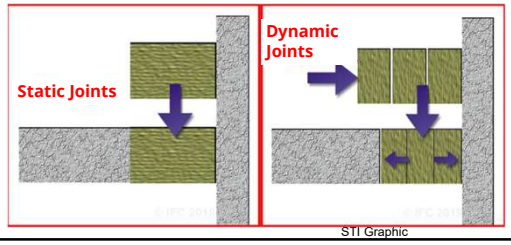
Typical Curtain Wall System Cont.

When movement is required, mineral wool must be inserted perpendicular to the joint for dynamic joints and compressed to the proper percentage



STI Graphic

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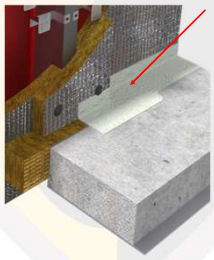
Typical Curtain Wall System Cont.



Min. 1/8 in. wet thickness spray applied over mineral wool overlapping onto concrete floor and curtain wall assembly. See listed system for correct overlap and spray applied thickness

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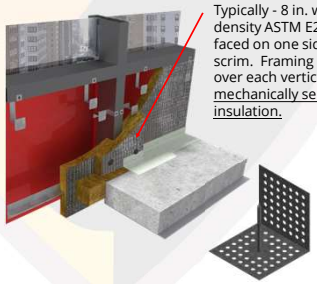
Typical Curtain Wall System Cont.



Typically - 8 in. wide x 2 in. thick, nom. 8 pcf density ASTM E2307 tested mineral wool faced on one side with aluminum foil scrim. Framing covers are to be centered over each vertical framing member and mechanically secured to the curtain wall insulation.

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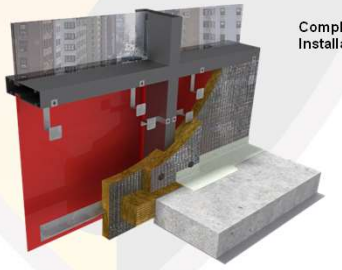
Typical Curtain Wall System Cont.



Completed Installation!

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Installation of Perimeter Barrier Safing

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PRESENTATION TITLE

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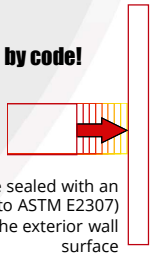
Extending the Rated Floor to the curtain wall...

Mandated by code!



The perimeter joint must be sealed with an approved PFC system (tested to ASTM E2307) that extends this rating to the exterior wall surface

162

Firestop Code Requirements - IBC

715.4 Exterior curtain wall/floor intersection. Where fire resistance-rated floor or floor/ceiling assemblies are required, voids created at the intersection of the exterior curtain wall assemblies and such floor assemblies shall be sealed with an *approved* system to prevent the interior spread of fire. Such systems shall be securely installed and tested in accordance with ASTM E 2307 to provide an *F rating* for a time period **not less than** the *fire-resistance rating* of the floor assembly. Height and fire-resistance requirements for curtain wall spandrels shall comply with Section 705.8.5.

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Firestop Code Requirements – IBC
Curtain wall to non-rated walls or floors

Joint between non-rated floors and curtain wall

715.4.1 Exterior curtain wall/nonfire-resistance-rated floor assembly intersections. Voids created at the intersection of exterior curtain wall assemblies and nonfire-resistance-rated floor or floor/ceiling assemblies *shall be sealed with an approved material or system to retard the interior spread of fire and hot gases between stories*.

Joint between interior rated wall and curtain wall

715.4.2 Exterior curtain wall/vertical fire barrier intersections. Voids created at the intersection of nonfire-resistance-rated exterior curtain wall assemblies and fire barriers shall be filled. *An approved material or system shall be used to fill the void and shall be securely installed* in or on the intersection for its entire length so as not to dislodge, loosen or otherwise impair its ability to *accommodate expected building movements and to retard the passage of fire and hot gases*.

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Perimeter fire containment does NOT prevent exterior fire spread

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Preventing exterior fire spread

- 705.8.5 – Vertical Separation of Openings -requires unprotected openings in exterior walls not separated horizontally by 5 ft to be:
  - Separated 3 ft (915 mm) minimum vertically by 1 hr wall (spandrel), or
  - 1-hr Flame barriers that extend min 30 in. (760 mm) beyond exterior wall (usually concrete balcony), or
  - These requirements waived if building is sprinklered and/or three stories of less
- Protects against exterior "leap-frog" fire spread
- 715.4.5 – Where section 705.8.5 does not apply, the requirements of section 715.4 shall still apply
  - Perimeter joint firestopping required regardless of what's done for exterior fire spread prevention

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Firestop Plan Review and Inspection

- Overview of Fire Compartmentation
- Through Penetration Systems
- Membrane Penetrations
- Fire Resistive Joint Systems
- **Perimeter Fire Containment Systems**
  - What is it?
  - Code Requirements
  - **Fire Testing**
  - Inspection
- Duct Enclosure Systems
- Understanding the UL Online Certifications Directory
- Special Inspection
- Engineering Judgments
- Inspection Tips and Techniques

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ASTM E2307

Standard Test Method for Determining Fire Resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multi-Story Test Apparatus

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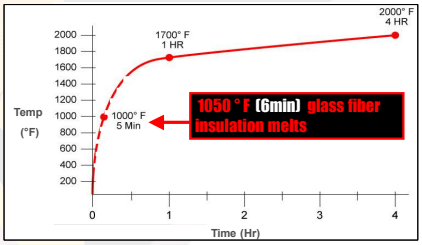
ASTM E2307 Time – Temperature Curve



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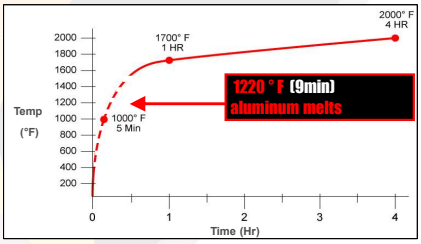
ASTM E2307 Time – Temperature Curve



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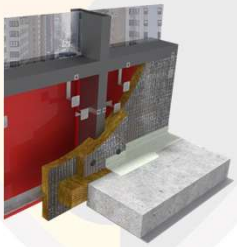
Factors Affecting Perimeter Joint Performance



- Floor and/or wall construction type and thickness
- Quality of Fire Barrier System Installation
- Stiffener Channel(s)/Attachment
- Spandrel Height
- Joint Width
- Movement requirements
- Firestopping materials

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Curtain Wall Test Assembly

Pre-Burn

- Transom above floor
- Mineral wool insulation at spandrel area
- Mechanical attachments supporting insulation
- Transom below floor
- Mullions

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Firestop Plan Review and Inspection

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Perimeter fire containment systems are highly detailed

1. What is the composition of the exterior wall?
   - Concrete panel, Spandrel Glass, Aluminum Panel, Brick Veneer, etc.
2. What supports the exterior wall?
   - Steel stud, aluminum mullions, etc.
3. What is the required hourly rating?
   - F rating (1 – 2 hour)
4. What is the joint width (inches)?
   - Measured from edge of slab to nearest point of curtain wall
5. How much movement is required?
   - Must accommodate building movement (% of joint size)
6. Are there any special considerations?
   - Unique construction conditions, environmental exposure
7. What reinforcement is required behind spandrel insulation?
8. What type of mechanical fasteners are required?
9. Is Mullion Cover protection required?
10. Has E2307 Compliant Materials been installed

174

Seems time consuming and complicated! ☹

What's the alternative to verifying that the proposed perimeter fire containment system is a full match to the field conditions?

175

Does the submitted perimeter fire containment system seem correct (in the right ballpark)?

Reading Intertek and UL Nomenclature

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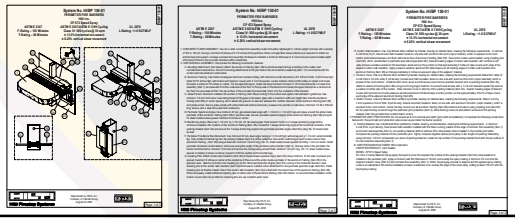
Intertek Design Nomenclature Example: HI-BP-150-01			
2-3 digit client reference	Code that ties to the CSI designation	Rating in minutes	Sequential number for design listing for particular client
HI (Hilti)	BP (Building Perimeter)	150	01



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UL Nomenclature

Navigating the UL Directory: **CW – D – 2005**

PERIMETER FIRE CONTAINMENT SYSTEMS (XHDG)

First Two Alpha Characters identify the type of system:

CW = Curtain Wall

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UL Nomenclature Cont.

Navigating the UL Directory: **CW – D – 2005**

PERIMETER FIRE CONTAINMENT SYSTEMS (XHDG)

Third Alpha Character identifies the movement capabilities of the system:

D = Dynamic (movement capabilities)

S = Static (no movement capabilities)

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UL Nomenclature Cont.

Navigating the UL Directory: **CW – D – 2005**

PERIMETER FIRE CONTAINMENT SYSTEMS (XHDG)

First Numeric Character identifies the nominal width of the linear opening:

0000 – 0999 = ≤ 2 in.

1000 – 1999 = > 2 in. and ≤ 6 in.

2000 – 2999 = > 6 in. and ≤ 12 in.

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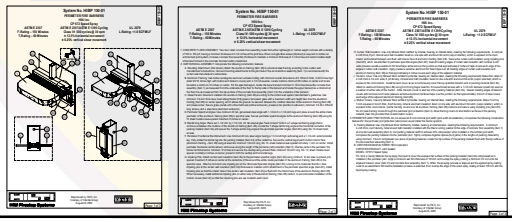
Intertek Design Nomenclature Example: HI-BP-150-01			
2-3 digit client reference	Code that ties to the CSI designation	Rating in minutes	Sequential number for design listing for particular client
HI (Hilti)	BP (Building Perimeter)	150	01



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Design Questions…

Question: Why aren't floor-to-wall (FW) systems acceptable for curtain walls?

Answer: Floor-to-wall systems test fire resistance between a ***rated*** floor and ***rated*** wall tested per ASTM E1966.

CW systems are specific perimeter tests between a ***rated*** floor and ***non-rated*** curtain wall using the Intermediate Scale Multi-story Apparatus (ISMA) per ASTM E2307.

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Additional Design Questions…

Question: What if the application isn't a perfect match for a system?

Answer: We *strongly* suggest specifying tested systems. However, real world designs are seldom a perfect match!

Manufacturers or Engineers can possibly provide an engineering judgment if a listed system is available that is *reasonably close* in construction

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Additional Design Questions…

Question: What if an Engineering Judgment is proposed that does not detail the curtain wall construction details?

Example EJ information:

1. **Floor Assembly**— Min 4-1/2 in. thick reinforced lightweight or normal weight (100-150 pcf) structural concrete
2. **Curtain/Window Wall Assembly-** Vision panel, design by others

Note-The F-rating of this system is dependent upon the performance of the untested component of this system, the window wall assembly (Item 2). The performance of the system will not exceed the performance of the untested component of the system, the window wall assembly (item 2).

Answer: ASTM E2307 test results are very strongly dependent on the exact construction details of the curtain wall itself. Any proposed EJ that does not detail the curtain wall construction, or that states that the proposed solution is "only as good as (dependent on) the fire performance of the wall" is really saying that the fire performance of the proposed perimeter fire containment is completely unknown.

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Firestop Plan Review and Inspection

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Duct Applications

- Commercial Kitchen Grease Ducts
- Ventilation Ducts

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Damper use Restrictions & Shaft Alternative

- Grease Ducts
- Stairwell Pressurization Ducts by design
- Hazardous Exhaust Ducts
- Dryer Exhaust Ducts
- Laundry and Refuse Chutes

In the absence of dampers, ducts need to either be "Fire Resistive" or protected by "Fire Resistance Rated" enclosures. Engineers & Architects may elect to use these in lieu of dampers & shafts

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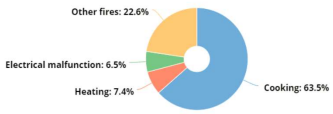
Grease Duct, the Numbers*

- For each year from 2010 to 2014, an estimated 7,410 restaurant fires resulting in three deaths, 110 injuries, and $165 million in property damage.
- Over 60% of restaurant fires were caused by cooking equipment
- Cooking materials (grease, oil) were the most frequent items first ignited

*Statistics from NFPA



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2018 IBC – Grease Duct

712.1.6 Ducts and air transfer openings. Penetrations by ducts and air transfer openings shall be protected in accordance with Section 717. Grease ducts shall be protected in accordance with the *International Mechanical Code*.

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2018 IMC – Grease Duct

506.3.6 Grease duct clearances. Where enclosures are not required*, grease duct systems and exhaust *equipment* serving a Type I hood shall have a *clearance* to combustible construction of not less than 18 inches (457 mm), and shall have a *clearance* to noncombustible construction and gypsum wallboard attached to noncombustible structures of not less than 3 inches (76 mm).

506.3.11 Grease duct enclosures – A …duct… that penetrates a ceiling, wall, floor, or any concealed space shall be enclosed from the point of penetration to the outlet terminal.

506.3.11.1 Shaft enclosure – ASTM E119 (UL 263)

506.3.11.2 Field-applied grease duct enclosure – ASTM E2336, E814 (UL1479)

Partial application of a field-applied grease duct enclosure shall not be installed for the sole purpose of reducing clearances to combustibles at isolated sections of grease duct.

506.3.11.3 Factory-built grease duct enclosure assemblies – UL2221, ASTM E814 (UL1479)

*Enclosure not required only if duct does not penetrate a ceiling, wall, floor or any concealed space

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2018 IMC – Grease Duct

506.3.12 Grease duct fire-resistive access opening.

Where cleanout openings are located in ducts within a fire resistance-rated enclosure, access openings shall be provided in the enclosure at each cleanout point. Access openings shall be equipped with tight-fitting sliding or hinged doors that are equal in fire-resistive protection to that of the shaft or enclosure. An *approved* sign shall be placed on access opening panels with wording as follows:

"ACCESS PANEL. DO NOT OBSTRUCT."

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2018 Uniform Mechanical Code Grease Duct

Part II – Commercial Hoods and Kitchen Ventilation

507.0 General Requirements

507.4 Clearance Where an enclosure are not required, hoods, grease removal devices, exhaust fans, and shall have a clearance of not less than 18 inches (457 mm) to combustible material, 3 inches (76 mm) to limited-combustible material, and 0 inches (0 mm) to noncombustible material. [NFPA 96:4.2.1]

507.4.4 Factory Built Factory-built grease duct enclosure shall be protected with a through-penetration firestop system classified in accordance with ASTM E814 or UL 1479 having an "F" and "T" rating equal to the fire resistance rating of the assembly being penetrated from the point at which the duct penetrates a ceiling, wall, or floor to the outlet terminal. The factory-built grease duct protection shall be listed in accordance with UL 2221. The factory-built grease duct protection system shall be installed in accordance with the manufacturers' installation instructions and the listing requirements. [NFPA 96:4.3.3]

507.4.4 Field Applied Field-applied grease duct enclosure shall be protected with a through-penetration firestop system classified in accordance with ASTM E814 or UL 1479 having an "F" and "T" rating equal to the fire resistance rating of the assembly being penetrated from the point at which the duct penetrates a ceiling, wall, or floor to the outlet terminal. The field-applied grease duct protection shall be listed in accordance with ASTM E2336. The factory-built grease duct protection system shall be installed in accordance with the manufacturers' installation instructions and the listing requirements. [NFPA 96:4.3.3.1]

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NFPA 96 – Grease Duct

NFPA 96 mirrors the IMC & UMC

4.3 Field-Applied and Factory-Built Grease Duct Enclosures.

4.3.1 Field-applied grease duct enclosures shall be protected with a through-penetration firestop system classified in accordance with ASTM E 814 or UL 1479 having an "F" and "T" rating equal to the fire resistance rating of the assembly being penetrated.

4.3.1.1 The surface of the field fabricated grease duct shall be continuously covered on all sides from the point at which the duct enclosure penetrates a ceiling, wall, or floor to the outlet terminal.

4.3.1.2 The field-applied grease duct shall be listed in accordance with ASTM E2336, and installed in accordance with the manufacturer's instructions and the listing requirements.

4.3.3.1 The factory-built grease duct protection system shall be listed in accordance with UL 2221.

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Fire Testing – ASTM E2336/UL 2221

Tested for fire exposure both inside and outside the duct separately

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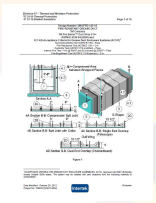
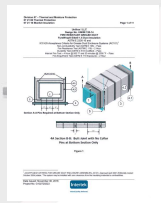
Laboratory Certifications





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Ventilation Ducts

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Code Requirements

- Shall enclosures shall be constructed as fire barriers
- Fire barriers must have a fire resistance rating per ASTM E119
- Fire barriers must comply with *ALL* parts of ASTM E119
- Systems not meeting temperature rise limits do not achieve a fire resistance rating
- No provisions in ASTM E119 to test a duct enclosure; ISO 6944 & ASTM E2816 are utilized – purpose built standards for ducts

Fire Resistance, n—the ability of a material, product, or assembly to withstand fire or give protection from it for a period of time. (Contrast fire resistance rating.) (2004)

DISCUSSION—As applied to elements of buildings, fire resistance is characterized by the ability to confine a fire or to continue to perform a given structural function, or both. More specific examples of this ability include retention of **stability** (loadbearing capacity), **integrity** or thermal **insulation**. Once a measure of time is defined for fire resistance, and exposure conditions specified for that measure, the result is a fire resistance rating. (2004)

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Determining Fire Resistance

703.3 Methods for determining fire resistance. The application of any of the methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. The required *fire resistance* of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

- 1. Fire-resistance designs document in approved sources.
- 2. Prescriptive designs of fire-resistance-rated building elements, components or assemblies as prescribed in section 721.
- 3. Calculations in accordance with Section 722.
- 4. Engineering analysis based on a comparison of building element, component or assemblies designs having *fire-resistance ratings* as determined by the test procedures set forth in ASTM E119 or UL 263.
- 5. Alternative protection methods as allowed by Section 104.11.
- 6. Fire-resistance designs certified by an approved agency.

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Demonstrating Equivalent Fire Resistance

Section 104.11 provides a path for alternative approaches…

104.11 Alternative materials, design and methods of construction and equipment. …..An alternative material, design or method of construction shall be *approved* where the *building official* finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, **at least the equivalent** of that prescribed in this code in quality, strength, effectiveness, ***fire resistance***, durability and safety.

Stability, integrity, and insulation requirements must be achieved

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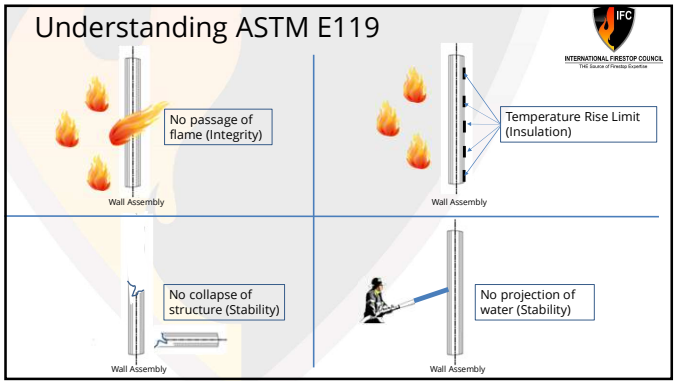
Understanding ASTM E119



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Real World Implications

- ASTM E119 tests flat walls and flat floors
  - Corners and connections not included
- ASTM E119 measures temperatures on unexposed (non-fire) side
  - Needed to achieve compartmentation
- ASTM E119 prohibits any flame passage to unexposed (non-fire) side
  - Needed to achieve compartmentation
- ASTM E119 requires structural integrity
  - Needed to achieve compartmentation
  - Prohibits collapse
- ASTM E119 requires a hose stream test
- ASTM E119 tests non-symmetrical walls twice
  - Once from each side, since simultaneous exposure from both sides is not possible
  - The rating is assigned based on the lesser of the two

ASTM E119: No provision for testing duct enclosures!

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Understanding ISO 6944 and ASTM E2816

- ISO 6944 and ASTM E2816 are both used to test Fire Resistive Ducts
  - Tests ducts with openings *or* ducts without openings
  - Tests at defined duct pressures and air flow rates
- Tests Duct Enclosure Systems in a fire engulfment test
  - Vertical or horizontal ducts
  - Includes the support system
  - Bends and connections
- Prohibits Duct Collapse
  - Needed for functional compliance
- Tests Through Penetration Firestop Systems
  - Needed for compartmentation

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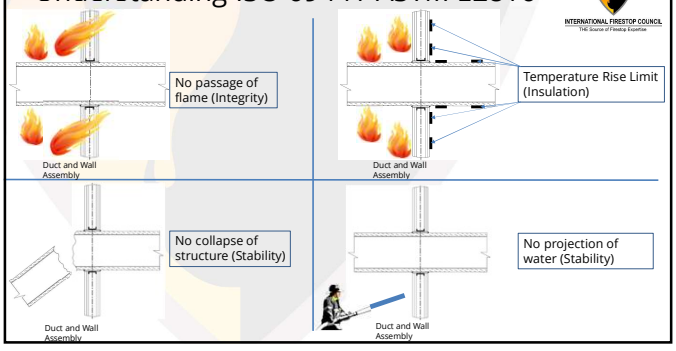
Understanding ISO 6944 / ASTM E2816



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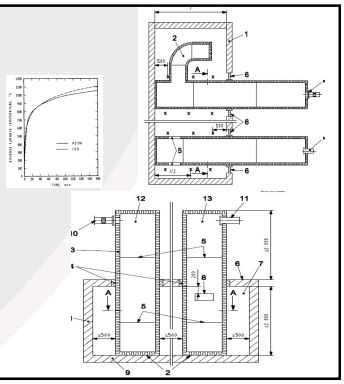
Fire Testing – ISO 6944

ISO 834 Time/Temp curve
- Duct A = without openings
  - Horizontal and vertical
  - Negative pressure in duct
- Duct B = with openings
  - Horizontal and vertical
  - Air velocity in duct
  - "fan off", "fan on" simulation



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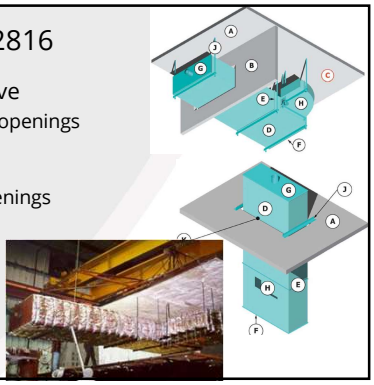
Fire Testing – ASTM E2816

ASTM E119 Time/Temp curve
- Conditions A&B = without openings
  - Horizontal and vertical
  - Negative pressure in duct
- Conditions C&D = with openings
  - Horizontal and vertical
  - Air velocity in duct
  - "fan off", "fan on" simulation



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Comparing ASTM E119 vs. ISO 6944 / ASTM E2816

Features	ASTM E119	ISO 6944	ASTM E2816
Unexposed Surface Temperature Limitation	Maximum 325°F Rise	Maximum 325°F Rise (Insulation)	Maximum 325°F Rise
Flaming on unexposed (non-fire) side	No	No (Integrity)	No
Tested with Through Penetrations	No	Yes	Yes
Prohibits Collapse	Yes	Yes (Stability)	Yes
Tested as Constructed in Field	No	Yes	Yes
Tested for Resistance to Load Effects	No	Yes	Yes
Performance Outputs	Single Rating (minutes/hours)	Stability and Integrity and Insulation	Single Rating (minutes/hours)

You can't pick and choose from these Features

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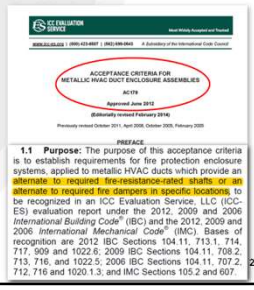
ICC-ES AC179

"Acceptance Criteria for Metallic HVAC Duct Enclosure Assemblies"

"This acceptance criteria has been issued to provide interested parties with guidelines for demonstrating compliance with performance features of the codes referenced in the criteria. The criteria was developed through a transparent process involving public hearings of the ICC-ES Evaluation Committee, and/or on-line postings where public comment was solicited."



ACCEPTANCE CRITERIA FOR METALLIC HVAC DUCT ENCLOSURE ASSEMBLIES

AC179

Approved June 2012

(Editorially revised February 2014)

PREFACE

1.1 **Purpose:** The purpose of this acceptance criteria is to establish requirements for fire protection enclosure systems, applied to metallic HVAC ducts which provide an alternate to required fire-resistance-rated shafts or an alternate to required fire dampers in specific locations, to be recognized in an ICC Evaluation Service, LLC (ICC-ES) evaluation report under the 2012, 2009 and 2006 *International Building Code*® (IBC) and the 2012, 2009 and 2006 *International Mechanical Code*® (IMC). Bases of recognition are 2012 IBC Sections 104.11, 713.1, 714, 717, 909 and 1022.6; 2009 IBC Sections 104.11, 708.2, 713, 716, and 1022.5; 2006 IBC Sections 104.11, 707.2, 712, 716 and 1020.1.3; and IMC Sections 105.2 and 607.

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ICC-ES AC179

AC179 utilizes ASTM E2816

Cross reference between ISO 6944 and ASTM E2816

Description	ISO 6944	ASTM E 2816
Horizontal – Duct w/o openings	Type A_{horz}	Condition A
Vertical – Duct w/o openings	Type A_{vert}	Condition B
Horizontal – Duct with openings	Type B_{horz}	Condition C
Vertical – Duct with openings	Type B_{vert}	Condition D

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ICC-ES Acceptance Criteria 179

ACCEPTANCE CRITERIA FOR METALLIC HVAC DUCT ENCLOSURE ASSEMBLIES

'Ducts with Fire Protection Enclosure Systems in lieu of Fire-resistance-rated Shaft Walls'

Test To ASTM E 2816 conditions B&D (These are analogous to ISO 6944 Type A_{vert} & Type B_{vert}) + ASTM E 814

'Fire Protection for Horizontal and Vertical HVAC Ducts with Dedicated Fire Protection Systems in Lieu of Required Fire Dampers'

Test To ASTM E 2816 conditions A&C (These are analogous to ISO 6944 Type A_{horz} & Type B_{horz}) + ASTM E 814

'Fire Protection for Horizontal and Vertical Stair or Elevator Hoistway Pressurization Systems with Dedicated Fire Protection Systems'

Test To ASTM E 2816 conditions A&B (These are analogous to ISO 6944 Type A_{horz} & Type A_{vert})

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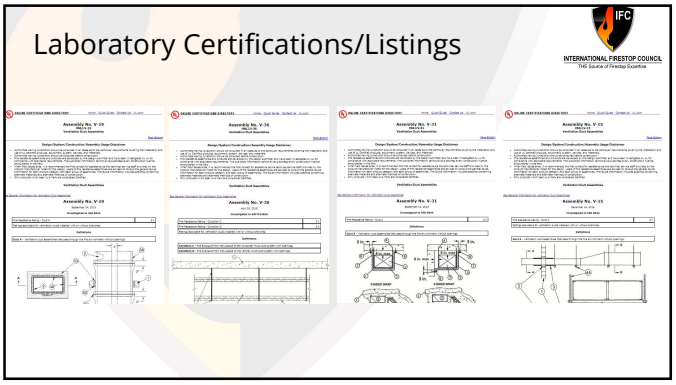
Laboratory Certifications/Listings



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Assembly No. V-6
HNLJ.V-6
Ventilation Duct Assemblies

Page Bottom

Design/System/Construction/Assembly Usage Disclaimer

- Authorities Having Jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of UL Certified products, equipment, system, devices, and materials.
- Authorities Having Jurisdiction should be consulted before construction.
- Fire resistance assemblies and products are developed by the design submitter and have been investigated by UL for compliance with applicable requirements. The published information cannot always address every construction nuance encountered in the field.
- When field issues arise, it is recommended the first contact for assistance be the technical service staff provided by the product manufacturer noted for the design. Users of fire resistance assemblies are advised to consult the general Guide Information for each product category and each group of assemblies. The Guide Information includes specifics concerning alternate materials and alternate methods of construction.
- Only products which bear UL's Mark are considered Certified.

Ventilation Duct Assemblies

See General Information for Ventilation Duct Assemblies

Assembly No. V-6
September 23, 2015
Investigated to ISO 6944

Fire Resistance Rating - Duct A	2 h
Fire Resistance Rating - Duct B	3/4 h
Ratings applicable for ventilation ducts installed with or without branches.	

Fire Resistance Rating is listed

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Assembly No. V-36
HNLJ.V-36
Ventilation Duct Assemblies

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Design/System/Construction/Assembly Usage Disclaimer

- Authorities Having Jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of UL Certified products, equipment, system, devices, and materials.
- Authorities Having Jurisdiction should be consulted before construction.
- Fire resistance assemblies and products are developed by the design submitter and have been investigated by UL for compliance with applicable requirements. The published information cannot always address every construction nuance encountered in the field.
- When field issues arise, it is recommended the first contact for assistance be the technical service staff provided by the product manufacturer noted for the design. Users of fire resistance assemblies are advised to consult the general Guide Information for each product category and each group of assemblies. The Guide Information includes specifics concerning alternate materials and alternate methods of construction.
- Only products which bear UL's Mark are considered Certified.

Ventilation Duct Assemblies

See General Information for Ventilation Duct Assemblies

Assembly No. V-36
November 16, 2017
Investigated to ASTM E2816

Fire Resistance Rating - Condition C	2 h
Fire Resistance Rating - Condition D	2 h
Ratings applicable for ventilation ducts installed with or without branches.	

Fire Resistance Rating is listed

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ONLINE CERTIFICATIONS DIRECTORY Home Quick Guide Contact Us UL.com

HNLN.V-5
Uninsulated Ventilation Duct Assemblies

Page Bottom

Uninsulated Ventilation Duct Assemblies

See General Information for Uninsulated Ventilation Duct Assemblies

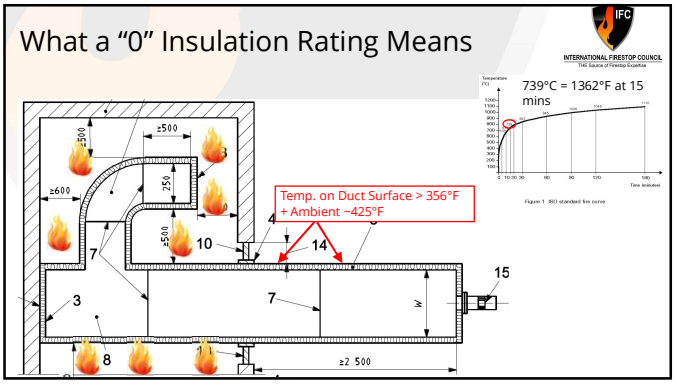
Assembly No. V-5
January 21, 2016

	Duct A	Duct B
Integrity and Stability rating	2 hr	2 hr
Insulation Rating	0 hr	0 hr
Ratings applicable for Ventilation Ducts installed with or without branches.		
Uninsulated ventilation duct assemblies are intended for use in environments where the clearance to combustible materials and combustible assemblies is at least 18 in.		

Shaft alternatives must fulfill all objectives of ASTM E119. Temperature rise requirements are never an exception (i.e. Insulation Rating)

214

What a "0" Insulation Rating Means



215

Closer look at "T-Rating"

- Not to be confused with Insulation Rating from ISO 6944/ASTM E2816
  - Recall earlier in the presentation, T-Rating not req'd when penetrating vertical assembly
  - The Insulation Rating from ISO/ASTM is always required as part of the Duct Assembly's Fire Resistance Rating
  - The T-Rating from E814 is required to maintain the rating of the assembly penetrated
- UL article: *Ducts – Providing Clarity on Fire Rated Ventilation Ducts and Assemblies*
  - Link to article: https://collateral-library-production.s3.amazonaws.com/uploads/asset_file/attachment/12040/the-fire-and-security-authority-May-2017.pdf

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Ventilation Duct Summary

- The code allows innovative approaches to be used provided they meet the full intent
- Other than code prescribed shafts or fire dampers, ALL other approaches must be pursued via the alternative methods approach
- Per section 104.11 Alternative Means and Methods, jurisdictions can approve systems tested to ISO 6944 and ASTM E2816
- Shaft alternatives must fulfill all objectives of ASTM E119. Temperature rise requirements are never an exception (i.e. Insulation Rating)

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Firestop Plan Review and Inspection

- Overview of Fire Compartmentation
- Through Penetration Systems
- Membrane Penetrations
- Fire Resistive Joint Systems
- Perimeter Fire Barrier Systems
- **Duct Enclosure Systems**
  - What is it?
  - Code Requirements
  - Fire Testing
  - **Inspection**
- Understanding the UL Online Certifications Directory
- Special Inspection
- Engineering Judgments
- Inspection Tips and Techniques

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Inspection

- Determine application – grease or air
- Ask for the tested listing
- Verify the proper material overlap, butt joints etc. for wrap systems
- Verify proper material attachment for wraps – banding, pins, etc.
- Verify proper product for prefabricated duct systems
- Check for clearances where required per listing
- If penetrating wall or floor assembly, same applies from "through penetration systems" discussed earlier
- Regardless of application grease or air, partial applications of product are not permitted on ducts for the purpose of reducing clearance to combustibles

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Firestop Plan Review and Inspection

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- Special Inspection
- Engineering Judgments
- Inspection Tips and Techniques

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Listing laboratories provide trustworthy, tested firestop designs

Fire Test ⇨ Test Report ⇨ Listing/Classification

- No need to blindly trust a manufacturer's or installer's firestop performance claims

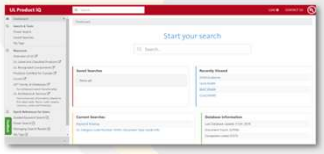
➔ Verify the published system listing for *exact* conformance to installed conditions

- Some firestop vendors or installers might use old system details that have since been modified or withdrawn completely
- Should not approve if no conformance between installation and referenced system
  - Another system might provide the needed compliance documentation (ask for it!)
  - If no matching system, installer would need to investigate possibility of Engineering Judgment

221

Where Can I Find The Most Current Listings?

UL (free account required)



https://iq.ulprospector.com/info/

INTERTEK

https://whdirectory.intertek.com/Pages/DLP_Search.aspx

222

"Guide Information" for each UL class of systems

- General installation and specification rules applicable to all systems listed in that Class
- Equipment, materials or systems included in the Category
- Intended use, restrictions or supplemental information that apply
- Standard(s) used to evaluate products under the Category
- Listing or Classification Mark information for the Category

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Examples of Guide Information for penetration firestop Systems (UL Listing category XHEZ)

- General Description of a Firestop System
- Standard
- Description of Ratings
- Permitted Substitutions
- Specifications of Penetrating Items
- Support of Penetrating Items
- Angle of Penetration
- Description of Numbering System

➔ Go to firestop.org/reading-list for links to all UL GuideInfo docs

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Existing Systems

There are thousands of Tested and Listed Systems:

Each one belongs to a particular manufacturer
And are tested ONLY for a particular product(s)

Different manufacturers' products may never be substituted into a design where it is not specified.

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UL terminology

- UL Approved — No Such Thing! (Only AHJ approves products/systems)

•UL Classified, Listed, Certified: all used somewhat interchangeably, depending on the product category

Common usage within firestopping:

- UL Classified — Lab has used the country requirements to evaluate the product for specific hazards or properties
- UL Listed — Firestop system has passed the standard fire resistance test and is in the lab's directory

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Searching the UL online directory

- Enter system number to retrieve system
- Enter listing category (e.g. XHEZ) to see and sort through all listings (7500+!!)

iq.ulprospector.com

Scroll down webpage for advanced search of
- *Firestop systems (penetrations)*
- *Joint systems*
- *Perimeter fire containment systems (curtain wall gap)*
- *Continuity Head-of-Wall Joint Systems*
- *All fire rated roofs, walls, floors, beams and columns*

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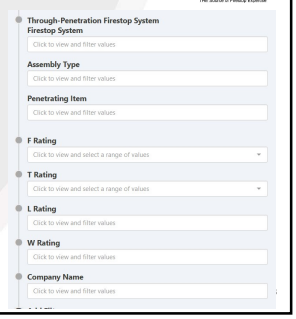
Searching the UL online directory

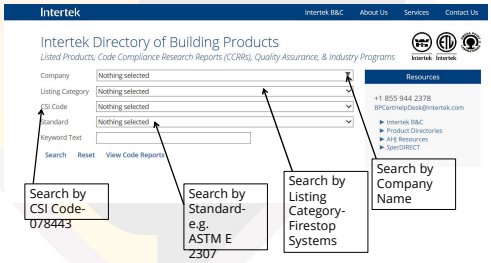
Example:
Firestop systems advanced search:

Via Direct link:
iq.ulprospector.com/en/_?tt=1027



228

Searching the Online Intertek Directory



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Firestop Plan Review and Inspection

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- Engineering Judgments
- Inspection Tips and Techniques

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Firestop Code Requirements - IBC

AHJ Inspections

- 110.3.6 Protection of joints and penetrations in fire-resistance-rated assemblies, *smoke barriers and smoke partitions* shall not be concealed from view until inspected and *approved*.

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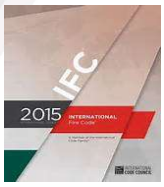
Firestop Code Requirements Fire Codes

Inspection during life of a building

- Fire codes govern the fire safety requirements of buildings throughout their lifespan
  - International Fire Code
  - NFPA 1



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International Fire Code (IFC)

Inspection during life of a building

701.6 Owner's responsibility. The owner shall maintain an inventory of all required fire-resistance-rated construction... Such construction shall be visually inspected by the owner annually and properly repaired, restored or replaced where damaged, altered, breached or penetrated. Records of inspections and repairs shall be maintained.

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International Fire Code (IFC)

Inspection during life of a building

SECTION 703 PENETRATIONS, 703.1 Maintaining protection.
Materials and firestop systems used to protect membrane and through penetrations in fire-resistance-rated construction and construction installed to resist the passage of smoke shall be maintained. The materials and firestop systems shall be securely attached to or bonded to the construction being penetrated with no openings visible through or into the cavity of the construction. Where the system design number is known, the system shall be inspected to the listing criteria and manufacturer's installation instructions.

SECTION 704 JOINTS AND VOIDS, 704.1 Maintaining protection.
Where required when the building was originally constructed, materials and systems used to protect joints and voids in the following locations shall be maintained. The materials and systems shall be securely attached to or bonded to the adjacent construction, without openings visible through the construction.

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3rd party inspections mandatory as of 2012 IBC

- Chapter 17: Special inspections and tests

  1705.17 Fire-resistant penetrations and joints. In high-rise buildings or in buildings assigned to *Risk Category* III or IV [Section 1604.5], special inspections for through-penetrations, membrane penetration firestops, fire-resistant joint systems, and perimeter fire barrier systems that are tested and listed in accordance with Sections 714.4.1.2, 714.5.1.2, 715.3 and 715.4 shall be in accordance with Section 1705.17.1 or 1705.17.2.
- Mandatory Independent 3rd Party Inspection
- All High-Rise and Risk Category 3 or 4 Buildings
- All tested/listed Firestopping Penetrations and Joints

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Risk category III buildings IBC 1604.5

Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to:

- public assembly > 300 occupants.
- elementary school, secondary school or day care > 250 occupants
- adult education > 500 occupants
- Group I-2 > 50 occupants, no surgery or emergency
- Group I-3 (prisons, jails)
- > 5,000 occupants
- Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Risk Category IV.
- Buildings/structures not included in Risk Category IV containing quantities of toxic or explosive materials that exceed certain thresholds and hazardous to public if released

OCCUPANT LOAD. The number of persons for which the *means of egress* of a building or portion thereof is designed.

236

Risk category IV buildings IBC 1604.5

Buildings and other structures designated as essential facilities, including but not limited to:

- Group I-2 occupancies having surgery or emergency treatment
- Fire, rescue, ambulance and police stations and emergency vehicle garages.
- Designated earthquake, hurricane or other emergency shelters.
- Designated emergency preparedness, communications and operations centers and other facilities required for emergency response.
- Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures.
- Aviation control towers, air traffic control centers and emergency aircraft hangars.
- Buildings and other structures having critical national defense functions.
- Water storage facilities and pump structures required to maintain water pressure for fire suppression.
- Buildings and other structures containing quantities of highly toxic materials that exceed certain thresholds and pose a threat to public if released

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General inspection requirements

1703.1.1 Independence. An *approved agency* shall be objective, competent and independent from the contractor responsible for the work being inspected. The agency shall also disclose possible conflicts of interest so that objectivity can be confirmed.

1703.1.3 Personnel. An *approved agency* shall employ experienced personnel educated in conducting, supervising and evaluating tests and/or inspections.

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General inspection requirements: Who pays?

1704.2 Special inspections. Where application is made for construction as described in this section, the owner or the *registered design professional in responsible charge* acting as the owner's agent shall employ one or more *approved agencies* to perform inspections during construction on the types of work listed under Section 1705. These inspections are in addition to the inspections identified in Section 110.

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General inspection requirements: Inspector qualifications

- 1704.2.1 Special inspector qualifications.

  The special inspector shall provide written documentation to the building official demonstrating his or her competence and relevant experience or training. Experience or training shall be considered relevant when the documented experience or training is related in complexity to the same type of *special inspection* activities for projects of similar complexity and material qualities. These qualifications are in addition to qualifications specified in other sections of this code.
- The *registered design professional in responsible charge* and engineers of record involved in the design of the project are permitted to act as the *approved agency* and their personnel are permitted to act as the special inspector for the work designed by them, **provided they qualify as special inspectors.**

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How is the inspection conducted?

1705.16.1 Penetration firestops. Inspections of penetration firestop systems that are tested and listed in accordance with Sections 714.3.1.2 and 714.4.1.2 shall be conducted by an approved inspection agency in accordance with ASTM E 2174.

1705.16.2 Fire-resistant joint systems. Inspection of fire-resistant joint systems that are tested and listed in accordance with Sections 715.3 and 715.4 shall be conducted by an approved inspection agency in accordance with ASTM E 2393.

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NFPA 1: Firestop QC Program + ASTM-compliant inspections for 3 stories and higher

12.3.2* Quality Assurance for Penetrations and Joints.
In new buildings three stories or greater in height, a quality assurance program for the installation of devices and systems installed to protect penetration and joints shall be prepared and monitored by the RDP responsible for design.
Inspections of firestop systems and fire-resistive joint systems shall be in accordance with 12.3.2.1 and 12.3.2.2.

A.12.3.2 The scoping provision of 12.3.2 is extracted from NFPA 5000, Building Construction and Safety Code, but limited to new buildings that are three or more stories in height. Such threshold is reasonable from the fire inspection perspective.

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NFPA 1 same as IBC: Penetrations to be inspected to ASTM E2174

12.3.2.1 Inspection of firestop systems of the types tested in accordance with ASTM E 814, *Standard Test Method for Fire Tests of Through-Penetration Fire Stops*, or /UL 1479, *Standard for Fire Tests of Through-Penetration Firestops*, shall be conducted in accordance with ASTM E 2174, *Standard Practice for On-Site Inspection of Installed Fire Stops*. [**5000:**40.9.1]

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NFPA 1 same as IBC: Joint systems to be inspected to ASTM E2393

12.3.2.2 Inspection of fire-resistive joint systems of the types tested in accordance with ASTM E 1966, Standard Test Method for Fire-Resistive Joint Systems, or UL 2079, Standard for Tests for Fire Resistance of Buildings Joint Systems, shall be conducted in accordance with ASTM E 2393, Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers. [5000:40.9.2]

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The special inspection process

- Statistical sampling
- Verify materials prior to installation
- Verify against listed systems and/or EJs
- Verify that ALL firestops installed

ASTM E2174: *Standard Practice for On-Site Inspection of Installed Fire Stops*
- For each "type" of firestop being installed:
  - Witness 10% of Installations, or
    Destructive Testing on 2% of Installations

ASTM E2393, Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers
- For each "type" of fire resistive joint system being installed:
  - Witness 5% of linear feet being installed, or
    Destructive (or disassembly) testing on 1 ft. per every 500 ft.

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If non-compliance identified

- One non-compliant:
  one full additional inspection of that type
- 10% non-compliance of one type:
  inspection halted, installer re-inspects own work
- Non-compliant firestop must be repaired/replaced
- E2174/E2393: no guidance on what is an acceptable non-compliance percentage

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ASTM E2174/E2393: Inspector Requirements

- Acceptable to AHJ
- Qualifications:
  - Meet the criteria in ASTM E699 (Construction Quality assurance agencies), OR
  - Min. 2 years construction inspection experience and credentials acceptable to Authorizing Authority, OR
  - Quality assurance agency accredited by AHJ (e.g. IAS AC291 – Special Inspection Agencies)
- No conflicts of interest
  - Completely independent of installer, contractor, manufacturer, or supplier of any material
  - Not a competitor to those above
  - Inspector to submit notarized statement indicating compliance
- Must not interfere or direct
- ASTM E3038 details the required firestop special inspector qualifications
  - Not yet referenced in ASTM 2174/2393 due to committee dysfunction

How do you decide if a proposed special inspector is acceptable?

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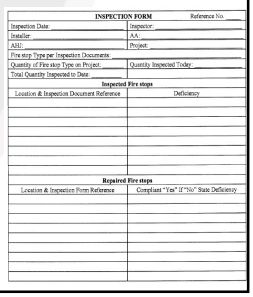
ASTM E 2174 and ASTM E 2393 Reporting/Inspection Forms

- Inspection Date
- Inspectors Name
- Project
- Reference No.
- Firestop type per Inspection
- Quantity of Firestop type on Project
- Quantity Inspected (the day of Inspection)
- Total Quantity Inspected to Date
- Locations of Inspected Firestop
- Deficiency (if non-compliant)


INSPECTION FORM

Reference No.

Inspection Date:

Inspector:

Installer:

AA:

AHJ:

Project:

Fire stop Type per Inspection Documents:

Quantity of Fire stop Type on Project:

Quantity Inspected Today:

Total Quantity Inspected to Date:

Inspected Fire stops

Location & Inspection Document Reference	Deficiency

Repaired Fire stops

Location & Inspection Form Reference	Compliant "Yes" if "No" State Deficiency

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ASTM E 2174 and ASTM E 2393 Final Report

Report should contain:

- Cover Page
- Name and Address of Inspector
- Name and Address of each firestop Installer, as well as the prime contractor
- Name and Address of the AA
- Name and Address of the AHJ
- Executive Summary outlining verification method used to ascertain compliance
- Notarized written statement of Conflict of Interest
- Summary of contain percentages of deficiencies
- All daily inspection reports

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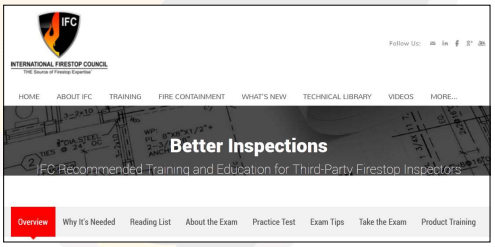
EDUCATION FOR THIRD-PARTY FIRESTOP INSPECTORS: IFC INSPECTOR TRAINING



FIRESTOP SPECIAL INSPECTION TRAINING CAN BE FOUND AT WWW.FIRESTOP.ORG/OVERVIEW

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IFC Education Program Overview

- Typical 1-day class is insufficient for a special inspector
- Comprehensive study material from multiple authoritative sources
- Only firestop inspector exam developed and written by
  - 3rd Party Firestop Inspectors
  - Manufacturers that develop the technology and test the firestop systems
  - Scientists and engineers experienced in firestop technology
- All reading curriculum relevant to firestop inspectors
- Online curriculum at no cost*

(ASTM inspection standards must be purchased from ASTM)

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IFC Education Program Overview (con't)

- Reading list of linked documents and videos
- Optional online proctored exam
  - Free practice test
- Passing the exam = Certificate of Achievement
  - Space to record hands-on product training from 4 IFC-member firestop manufacturers
- AHJs: Ask inspectors for their IFC education program certificate!

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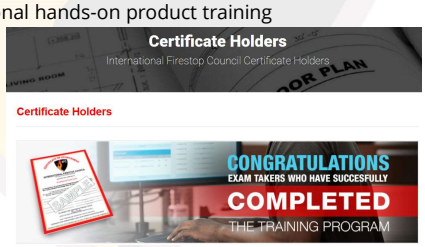
Verifying whether someone has passed the IFC inspector exam

- www.firestop.org/certificate-holders
  - Premier certificate holders: additional hands-on product training



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Intertek IQP Program Qualified Firestop Inspector

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IQP Differentiator

	Experienced Inspector/Installer	IFC Training	Intertek
Industry Experience	X	X	X
Formalized Training		X	X
Required Retesting		X	X
Regular Quality Audits			X
Inspector Network			X
Backing of Intertek			X

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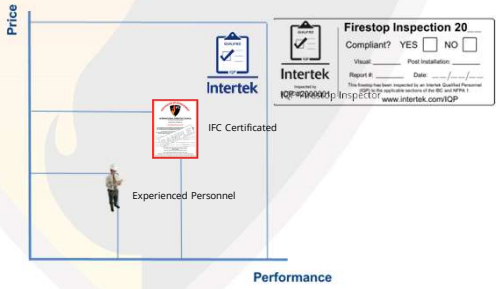
IQP Differentiated: Firestop Inspectors



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Special Inspection Agency accreditation IAS AC291

- International Accreditation Service, Inc. "ACCREDITATION CRITERIA FOR SPECIAL INSPECTION AGENCIES"
- Accreditation of company, not of individual inspectors
- Requires one employee to have passed UL Firestop Examination or FM Firestop Examination or IFC Firestop Special Inspector Examination.
- **Potential conflict with ASTM E2174/E2393 conflict of interest mandates***

6.2.2 *Conflicts of Interest:*

6.2.2.1 The contract inspector shall be completely independent of, and divested from, the installer, contractor, manufacturer, or supplier of any material being inspected.

6.2.2.2 The contract inspector shall not be a competitor of the installer, contractor, manufacturer, or supplier of any material being inspected.

***potential conflict of interest if the agency with AC291 is a contractor or installer**

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Special inspections summary

- Since 2012 IBC makes firestop special inspection mandatory for high-rises and Risk Category III and IV buildings
- Approved agency shall be objective, competent and independent
- Special inspector shall provide written documentation to building official demonstrating competence and relevant experience or training
- Property owner pays for inspection
- Inspection per ASTM E2174, E2393
- IFC program provides both education and needed written documentation/examination

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- Special Inspection
- **Engineering Judgments**
- Inspection Tips and Techniques

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Engineering Judgments:

- What are they?
- When are they acceptable?
- When are they not appropriate?
- What are the guidelines?

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Engineering Judgments

- An Engineering Judgment is a letter or report issued by some knowledgeable party which evaluates construction of some site-specific application which deviates from a tested design, system or assembly and concludes with a judgment of the applicable rating of that assembly
- Engineering Judgments are commonly called EJ's.
- EJ should NOT be a guess of how some different condition would perform *if it were to be fire tested*
  - Some evidence leading to that conclusion should be expected and provided

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Engineering Judgments Cont.

- Most often applied to fire resistive construction
- Applications for an Engineering Judgment
  - Design and system concept where multiple components, some listed and some unlisted, are used to field construct the finished assembly (e.g. wall)
  - Typically products are not required by code to be listed
- Contractor or architect initiates process

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Engineering Judgments Cont.

- Engineering Judgment letter issued, summarizing construction and making conclusion on applicable rating
- AHJ makes decision on validity of Engineering Judgment letter and if approved, inspects construction for consistency with letter
- Discussion: who critically reviews and Approves proposed EJs in your jurisdiction?

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Who Issues Engineering Judgments?

- Manufacturer
- Fire protection engineer
- Professional engineer
- Testing laboratory

- Must be acceptable to the Building Official or the AHJ

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When are they acceptable?

- When tested systems do not exist
- When modifying the application is unrealistic
- When existing test data supports the interpolation
  - Referenced listing numbers should be included on the Engineering Judgment
- When the author has experience with the performance of the system and knowledge of the conditions

  Prove it!
  - IFC EJ Guidelines state that a proper EJ should include "Reference tested system(s)upon which design (EJ) is based on"
  - Is the EJ truly *close enough* to the referenced listings?
  - Ask for some evidence if "internal testing" is a key justification
- When issued only for a specific jobsite

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Important Points of an Engineering Judgment

- No guidance from the International Code Council nor from the various I-Codes
- No guidance from UL
- Most relevant documents available are from the International Firestop Council (IFC)
  www.firestop.org/**engineering-judgment**-guidelines.html

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IFC Engineering Judgment Guidelines

Four Documents

- Recommended IFC Guidelines for Evaluating Firestop System Engineering Judgments
  - Covers firestops, joint systems
- Recommended IFC Guidelines for Evaluating Firestop Systems in EJs – Perimeter Fire Barrier Systems (a.k.a. perimeter fire containment systems or perimeter joints)
- Recommended IFC Guidelines for Evaluating Firestop Systems in EJs – Air Ducts
- Recommended IFC Guidelines for Evaluating Firestop Systems in EJs – Grease Ducts

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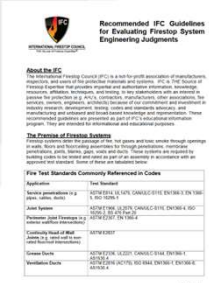
IFC Engineering Judgments Guidelines

- According to the International Firestop Council:
  "listed firestop systems can be broadened within the context of their originally tested and rated conditions through the careful and restricted application of accepted engineering principles and fire protection testing guidelines."
- Download IFC Guidelines at:
  www.***firestop***.org/***engineering-judgment-guidelines***


Recommended IFC Guidelines for Evaluating Firestop System Engineering Judgments

About the IFC

The Premise of Firestop Systems

Fire Test Standards Commonly Referenced in Codes

Application	Test Standard
Service penetrations (e.g. pipes, cables, ducts)	ASTM E814, UL 1479, CAN/ULC-S115, EN1366-3, EN 1366-5, ISO 10295-1
Joint System	ASTM E1966, UL 2079, CAN/ULC-S115, EN1366-4, ISO 10295-2, BS 476 Part 20
Perimeter Joint Firestops (e.g. curtain wall/floor intersections)	ASTM E2307, EN 1366-4
Continuity Head of Wall (e.g. curtain wall/floor rated floor/roof intersections)	ASTM E2307
Grease Ducts	ASTM E2336, UL2221, CAN/ULC-S144, EN1366-1, ASHRAE 6
Ventilation Ducts	ASTM E2336 (ACCP), ISO 6944, EN1366-1, EN1366-8, ASHRAE 6

Rev 2016.01

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WHAT CAN BE DONE TO REDUCE QUESTIONABLE EJ'S?

THE UL TECHNICAL EVALUATION DEVELOPER PROGRAM

Firestop Plan Review and Inspection 269

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UL Technical Evaluation Developer Program (TEDP)

- What the Program is
- What the Program is not
- Hierarchy of the Program Participants

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TEDP - What the program is

- Self-governed process guided by a management system
- Management system adherence with oversight by UL through routine audits
- Recognition of qualified personnel through subject matter testing and demonstrated experience
- Verification of Quality Assurance through random fire testing of Technical Evaluations
- Applicable to all TE's whether based on UL or other 3rd party systems.
- An international program.

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TEDP - What the program is not

- UL approval of technical evaluations
- A replacement for engineered systems developed by licensed professional engineers
- An authorization or determination of suitability

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TEDP – Hierarchy of the Program

- Program Administrator (UL)
- Manufacturer organization (listed in UL directory)
- Manufacturer's Authorized Representative (MAR)
  - Managing the TE developer team
  - Adherence to the management system
  - Liaison with UL, audit contact
  - Manage/track TE team CEUs
- Technical Evaluation Developer (TED)

273

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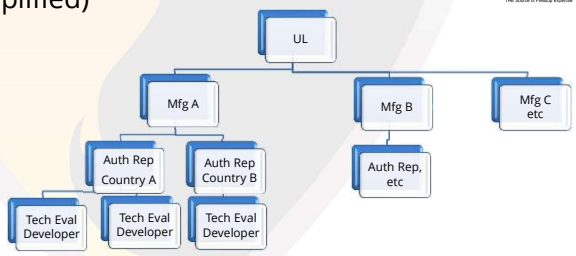
TEDP – Hierarchy of the program (simplified)



274

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REVIEW

- AHJ's are the approving body for Engineering Judgments
  - AHJ's are not obligated to approve an Engineering Judgment
  - Is the proposed EJ truly "close enough" to the referenced fire tests?
  - Be critical! Ask questions!
- It is not appropriate to accept an Engineering Judgment if there are available tested and listed systems
- UL's *Technical Evaluation Developer Program* should increase quality, consistency and reliability of EJs

275

Firestop Plan Review and Inspection

- Overview of Fire Compartmentation
- Through Penetration Systems
- Membrane Penetrations
- Fire Resistive Joint Systems
- Perimeter Fire Barrier Systems
- Duct Enclosure Systems
- Understanding the UL Online Certifications Directory
- Special Inspection
- Engineering Judgments
- **Inspection Tips and Techniques**

276

IFC Video
Inspecting Firestop for Compliance
(19 mins, if time permits)

Low-res (unfortunately) at YouTube
https://youtu.be/UsaVu5pSgaU

277

RECOGNIZING FIRESTOP INSTALLATION PROBLEMS

278

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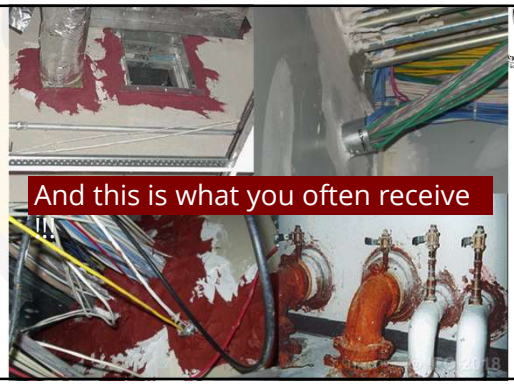


280

Firestopping in the Real World

- Firestop system details are hardly ever on plans
- Code Officials generally do not ask for copies of approved firestop systems
- Tested/Listed systems rarely installed correctly
- Joints are generally not inspected during the framing inspection and installed to provide movement
- Engineering judgments are being used when there are tested and listed systems available
- Firestopping considered beneath contractors
- Most users are untrained
- No Licensed firestop contractors

Discussion: how can each of these be solved?

281

AHJ Plan Review and Inspection Process recommendations

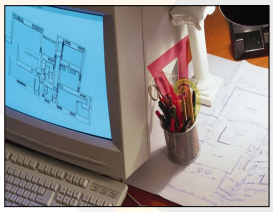
282

Pre-Construction Meeting

- Review Design Drawings Submittals
- Obtain Pre-Approved Engineering Judgments
- Establish inspection guidelines and expectations
- Review qualifications/experience of firestop installers
- Schedule firestop Inspections
- Review qualifications/experience of special inspectors (if applicable)

283

PROCESS
Building Department Submittals



- 107.2.1 - … Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code

284

PROCESS
Plans Examination/Review

- Firestop systems details should be included on the plans and specifications (Project Documents)
- Recommended to have all firestop Details reproduced, including the system number for firestop applications on the plans
- Firestopping is often a "deferred submittal" – available only later on in the project

285

PROCESS
Plans Examination/Review Cont.

- For unique conditions have policy for Engineering Judgments
- The structural engineer should specify amount of movement required for all joints
- Consider requiring special inspection for firestopping on large projects
- Require or encouraging use of Firestop Qualified Contractor

286

Firestop Systems
Recommended Correction Notice

- All firestop systems for fire rated construction need to be reproduced on the plans as tested by an approved testing laboratory. If an EJ is needed, it must be noted on plans and this system must be approved by Building Official.
- The above information must be provided for the field inspectors.

287

Inspection Practices for Firestopping

- Inspections typically done by AHJ, but may be inspected by approved agency or individual
- Require construction documents that detail all firestop locations and systems
- During framing inspection observe that joints are installed in manner that required movement can be achieved

288

Inspection Practices for Firestopping Cont.

- Observe the products, empty containers or boxes for label with name, description and approved testing agency
- Have your inspection tools such as a flashlight, coring device, wire, tape measure and other appropriate tools
- General Contractor should understand that you may require a ladder or lift

289

Inspection Practices for Firestopping Cont.

- Verify firestopping was installed in accordance with the published system
- Verify who did installation of systems to determine reasonable verification
- When necessary destructive evaluation will be made on various types of systems
- During inspection have firestop contractor follow-up to repair systems after destructive testing

290

Inspection Practices for Firestopping Cont.

- What to do if firestopping is not acceptable:
  - Notify ALL effected persons of deficiencies in a timely manner.
  - If firestop system is repaired (not replaced) the manufacturers need to recommend proper procedures and methods
  - Will require more inspections to verify compliance
  - Observe firestop contractor re-doing the non-compliant installation.
  - May need to "Stop Work" on part of the project
  - Re-inspect when appropriate and thank personnel effected by the delay of the project.

291

FREQUENTLY ASKED QUESTIONS

292

Frequently Asked Questions?

ARE ALL FIRESTOP SEALANTS EQUAL?

• NO. Each manufacturer's material has its own unique properties and functions when applied in a firestop system design.

• Similar firestop products cannot be used interchangeably

• Each firestop system must be judged on its own merits and within the parameters of each manufacturer's system specific design

293

Frequently Asked Questions?

IS MINERAL WOOL 1-HOUR RATED?

• NO. Mineral wool is a component of many firestop systems but is normally used in conjunction with sealants or coatings
• Mineral wool alone does not pass the hose stream test

• Mineral wool alone will not provide a smoke seal

294

Frequently Asked Questions?

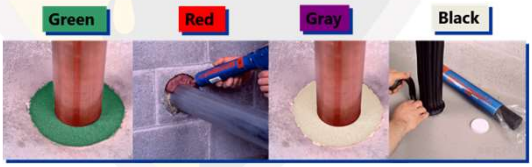
WHAT IS THE FIRE RATING FOR YOUR CAULK?

- Firestopping products do not have a fire rating (e.g. 1" of caulk does not equate to a 1 hr rating, etc.)
- The assembly in which it is installed has the fire rating
- The thousands of different firestop systems each detail the required parameters and building components

295

Are firestop caulks required to be RED?

Answer: There is NO building code requirement anywhere that mandates product color. However, most manufacturers deliberately use colors that stand out to facilitate inspection and different colors to distinguish between products.



296

Is safing insulation an adequate firestop?

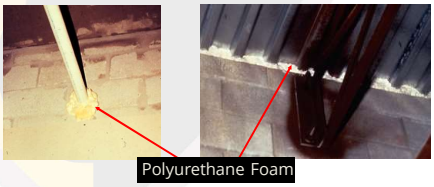
Answer: Fire safing, or packing an opening with mineral wool is certainly better than nothing, but is *not* a firestop. Using only mineral wool does not provide a *smoke seal,* does not address combustible penetrants and cannot withstand the shock from the hose stream.

Fire blocking or safing with wool

297

FICTION: Polyurethane foam is a firestop.

FACT: Polyurethane foams, frequently used as draft stops, burn vigorously and are not generally not acceptable firestopping materials. Some are UL Classified for surface flammability only, but typically are not fire resistant.



298

Visual vs destructive inspection

- Visual inspection often sufficient for:
  - Pre-formed firestop devices e.g. collars, cast-in, cable sleeve devices
  - Pre-formed joint systems
  - Mechanical Joints
- Destructive inspection needed for
  - Firestop sealant depth (wet vs dry)
    - Look for movement during cure
  - Mineral wool depth, compression, orientation

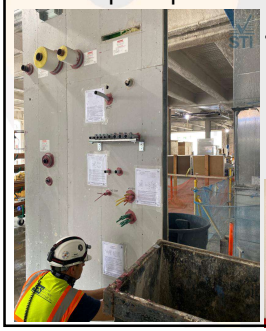
299

Firestop Inspection Best Practices

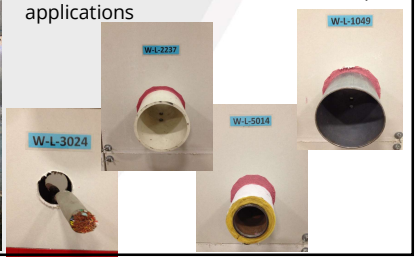
- Pre-construction Firestop Meeting with all Trade firestop installers to make sure inspection process works properly.
- Have clearly marked set of drawings highlighting fire and smoke walls along with approved firestop submittals

300

Firestop Inspection Best Practices (con't)



- Have firestop mock ups built that would show construction of foreseen firestop applications



301

Firestop Inspection Best Practices (con't)

- Have contractors Identify each installed firestop system by labeling or other methods.

302

302

Firestopping is only installed to the level of knowledge of the AHJ

- You are the last line of defense!
- You need to ensure:
  - The code is enforced
  - Contractors do the job per specifications
  - Buildings are safe for occupants and first responders

303

Question for your Building Official

- What is our Building Department's Plan Review and Building Inspection Policy and Procedure for Firestopping?

304

During last break of the afternoon....

- Please take our seminar feedback survey:

Paper copy
or
https://www.surveymonkey.com/r/FirestopSeminar
(only 3-4 mins!)

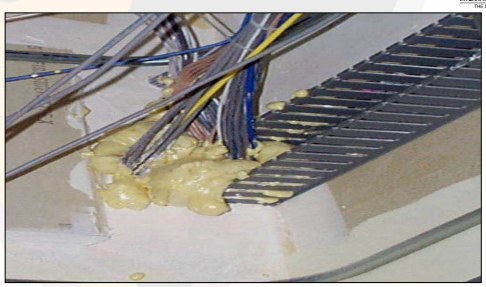
You can scan the QR code to take you to the survey

305

Improper Firestop Installations: What it should not look like

306

Improper Firestop Installations



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Improper Firestop Installations

308

Improper Firestop Installations

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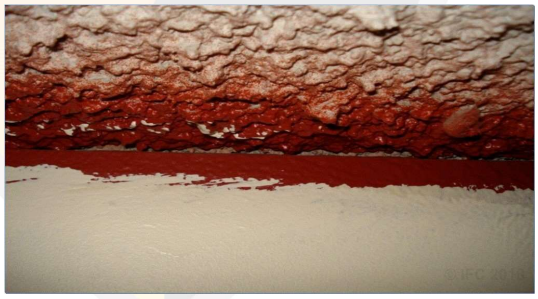
Improper Firestop Installations

310

Improper Firestop Installations



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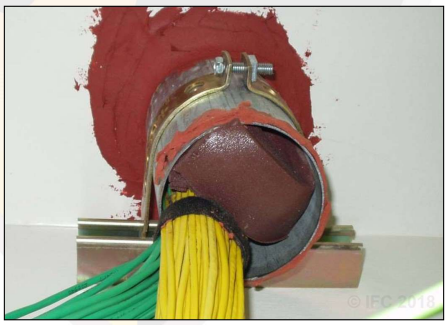
Improper Firestop Installations



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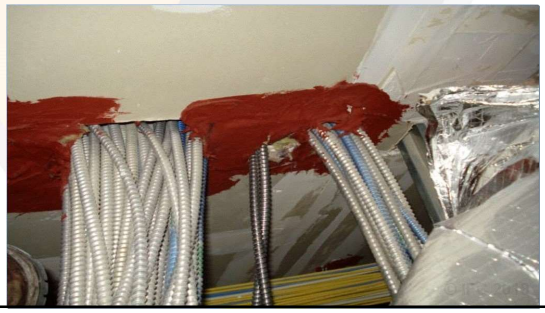
Improper Firestop Installations



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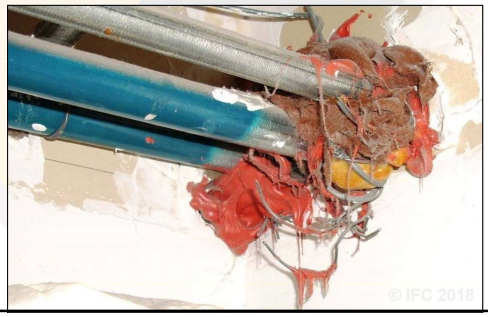
Improper Firestop Installations

314

Improper Firestop Installations

315

Improper Firestop Installations



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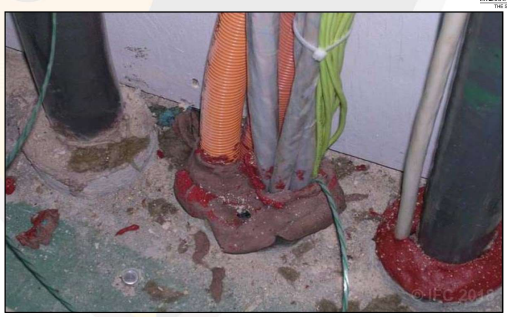
Improper Firestop Installations



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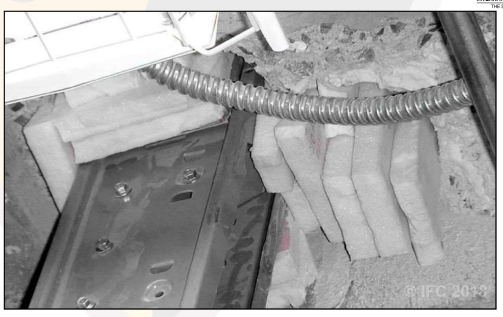
Improper Firestop Installations

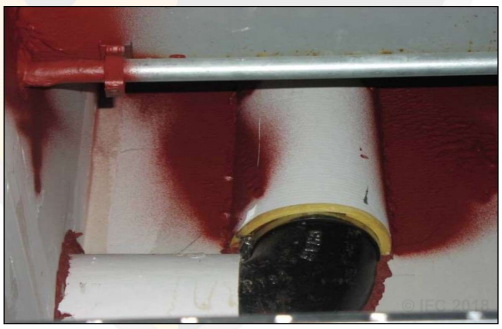


318

Improper Firestop Installations

319

Improper Firestop Installations

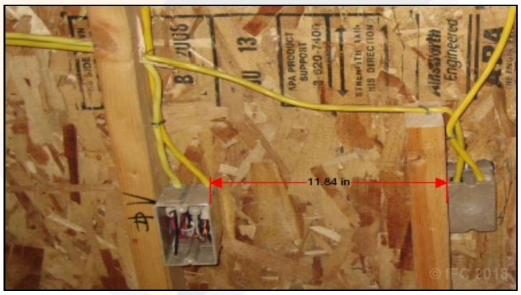


320

Improper Firestop Installations

321

Improper Firestop Installations



322

Improper Firestop Installations

323

Improper Firestop Installations

324

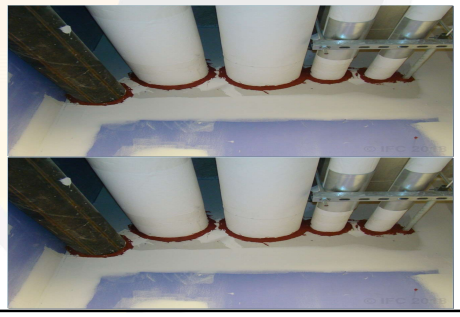
Improper Firestop Installations

325

Improper Firestop Installations

326

Questionable Firestop Installation



327

Correct Firestop Installations

328

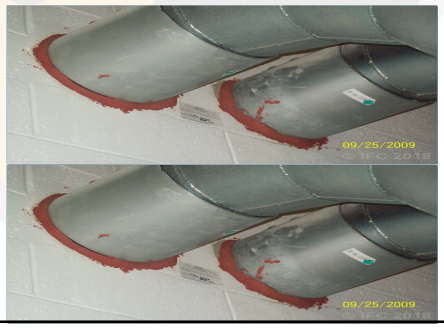
Correct Firestop Installations

329

Correct Firestop Installations

330

Correct Firestop Installations



331

Correct: First Floor
Underside of curtain wall joint

332

Correct: Second Floor
Top side of curtain wall Joint

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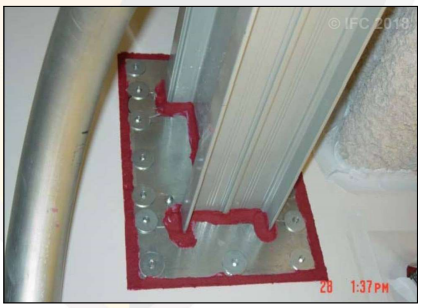
Correct Firestop Installations

334

Correct Firestop Installations

335

Correct Firestop Installations



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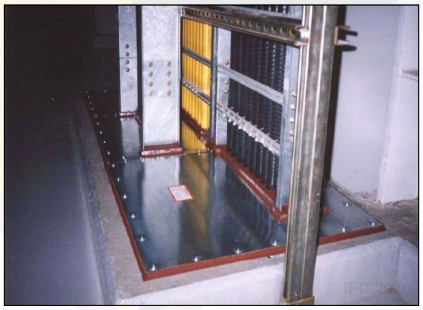
Correct Firestop Installations



337

Correct Firestop Installations

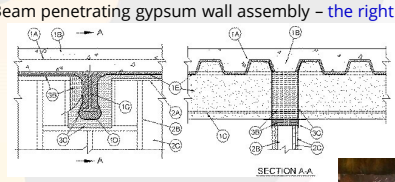
338

Correct Firestop Installations

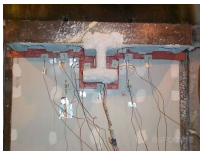
339

Common Mis-installed Conditions

Beam penetrating gypsum wall assembly – the right way!



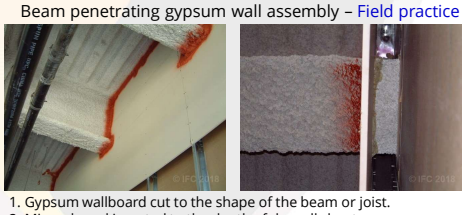
1. Frame studs around beam or joist
2. Tightly compress mineral wool below and on sides of beam/joist
3. Spray coating over mineral wool overlapping wall and fireproofing



340

Common Misinstalled Conditions

Beam penetrating gypsum wall assembly – Field practice



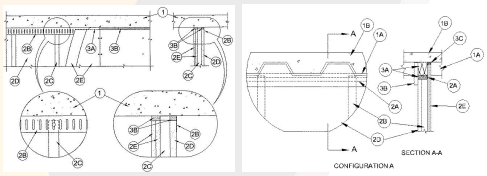
1. Gypsum wallboard cut to the shape of the beam or joist.
2. Mineral wool inserted to the depth of drywall sheet
3. Firestop coating sprayed over mineral wool with little overlap on fireproofing and wall

There are no listed systems that permit this !!!

341

Common Mis-installed Conditions

Gypsum shaft wall assembly



- Typically install fire sealant on finish of wall only. Fire sealant is required on both the finish side of wall and above shaft liner within wall cavity.
- J-Runner Track with 1" front leg installed for the head-of-wall joint will not provide a long enough track leg to provide backing for the head of wall joint. Slotted track or longer leg (1-1/2" leg) J-Runner Track should be used
- J-Runner Tracks Space above 1" liner board inside the J runner must also be protected (usually with sealant) otherwise fire has direct path in from shaft side
- Impossible to inspect inside wall cavity after wallboard is installed (must do during construction)

342

Visual Inspection Quiz
What's wrong with these installs?


Dissimilar products in the same opening is not allowed

343

Visual Inspection Quiz
What's wrong with these installs?

Drywall compound is never an acceptable firestop material

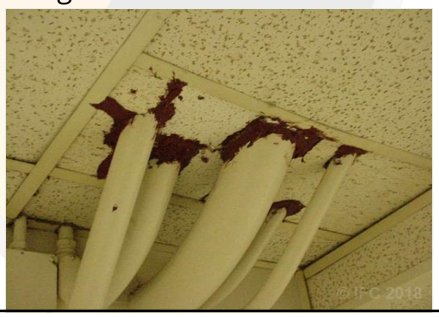
Collar must be flush with ceiling surface

344

Visual Inspection Quiz
What's wrong with this install?

345

Visual Inspection Quiz
What's wrong with this install?



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Visual Inspection Quiz
What's wrong with this install?

Head of wall joint is firestopped, but penetrations are not

Penetrant opening at top of wall must be firestopped with same product as head of wall

Gysum repair must meet GA-225,
e.g. studs to support patch

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Visual Inspection Quiz
Is there anything wrong with these installs?

Does thickness and overlap of coating match design?

What type and amount of backing material is behind coating?

Visually ... Nothing

Does number and type of wrap strip match design?

Is there sealant in the void?

348

Firestopping Code Changes 2009, 2012, 2015, 2018 IBC

Are you enforcing the latest provisions?

349

Barrier Identification

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IBC Barrier Marking (since 2009 IBC)

- IBC Section 703.7 Marking and Identification.
  - Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings or penetrations shall be effectively and permanently identified with signs or stenciling.

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IBC Barrier Marking

Such Identification shall be located in accessible concealed floor, floor ceiling or attic spaces.

- Within 15 feet (4572 mm) of the end of each wall and at intervals not exceeding 30 feet (9144 mm) measured horizontally along the wall or partition
- Include lettering not less than 3 inches (76 mm) in height with a minimum 3/8 inch (9.5 mm) stroke in a contrasting color incorporating the suggested wording:
  FIRE AND/OR SMOKE BARRIER—PROTECT ALL OPENINGS

352

International Fire Code (IFC)

Inspection and Maintenance of buildings

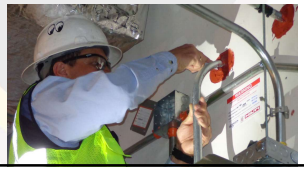
- 703.1 Maintenance. The required fire-resistance rating of fire-resistance-rated construction (including walls, firestops, shaft enclosures, partitions, smoke barriers, floors, fire-resistive coatings and sprayed fire-resistant materials applied to structural members and fire-resistant joint systems) shall be maintained.

- 2009 IFC addition:
  Building owners to annually inspect all fire-resistance-rated construction including firestops and joint systems
  - Firestopping needs to be properly repaired, restored or replaced when damaged, altered, breached or penetrated.

353

Firestopping Special Inspections Approved in 2012 IBC

- **1705.16 Fire-resistant penetrations and joints.** special inspections for through-penetrations, membrane penetration firestops, fire resistant joint systems, and perimeter fire barrier systems that are tested……
- Required for buildings over 75 ft. and for Category 3 and 4 buildings
- ASTM Inspection Standards ASTM E 2174 and ASTM E 2393 are required



354

2012 New penetration T-rating exception

- 2009: 1. Floor penetrations contained and located within the cavity of a wall above floor or below the floor do not require a T-Rating

- 2012 IBC: 2. Floor penetrations by floor drains, tub drains or shower drains contained and located within concealed space of a horizontal assembly do not require a T-Rating.

355

2015/18 New penetrations T-rating exception

- 2015 IBC:
  3. Floor penetrations of maximum 4-inch (102 mm) nominal diameter penetrating directly into metal-enclosed electrical power switchgear do not require a T-Rating.
- 2018 IBC: clarified that penetrant is to be metal conduit or tubing.

356

2009 IBC: 24 inch rule only for "non-communicating stud cavities"

714.3.2 Membrane penetrations. Membrane penetrations shall comply with Section 713.3.1. Where walls or partitions are required to have a *fire-resistance rating*, recessed fixtures shall be installed such that the required fire-resistance will not be reduced.

Exceptions:

1. Membrane penetrations of maximum 2-hour fire-resistance-rated walls and partitions by steel electrical boxes that do not exceed 16 square inches (0.0103 m2) in area, provided the aggregate area of the openings through the membrane does not exceed 100 square inches (0.0645 m2) in any 100 square feet (9.29m2) of wall area.

357

2009 IBC: 24 inch rule only for "non-communicating stud cavities"

Such boxes on opposite sides of the wall or partition shall be separated by one of the following:

1.1. By a horizontal distance of not less than 24 inches (610 mm) where the wall or partition is constructed with individual noncommunicating stud cavities;

358

Staggered stud walls must use an alternative to 24 inch separation

Such boxes on opposite sides of the wall or partition shall be separated by one of the following:

- 1.1 By a horizontal distance of not less than 24 inches (610 mm) where the wall or partition is constructed with individual noncommunicating stud cavities;
- 1.2. By a horizontal distance of not less than the depth of the wall cavity where the wall cavity is filled with cellulose loose-fill,
- rockwool or slag mineral wool insulation;
- 1.3. By solid fireblocking in accordance with Section 717.2.1;
- 1.4. By protecting both outlet boxes with listed putty pads; or
- 1.5. By other listed materials and methods.

359

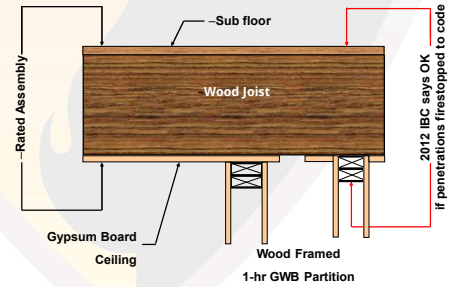
IBC 2012 changes: Code clarity Firestopping of double top plate

- Membrane penetrations of horizontal assemblies, new exception:
  714.4.1.2
  Exception 7. The ceiling membrane of 1- and 2-hour fire-resistance rated horizontal assemblies is permitted to be interrupted with the double wood top plate of a fire resistance rated wall assembly, provided that all penetrating items through the double top plates are protected in accordance with 714.4.1.1.1 or 714.4.1.1.2.
- 714.4.1.1 = penetration tested as part of assembly
- 714.4.1.2 = penetration firestopped

See Drawing.....

360

Wood Composite Floor/Ceiling System



361

Continuity head-of-wall joints

- IBC 2012
- 707.9 Voids at intersections

  The voids created at intersection of fire barrier and non-fire resistance rated roof assembly shall be filled. An approved material or system shall be used to fill the void, shall be securely installed in or on intersection for its entre length so as not to dislodge, loosen or otherwise impair its ability to accommodate expected building movements and to retard the passage of fire and hot gases.
- Tested system NOT required
- Listed system instead of EJs:
  - Approval should be easier/faster
  - Save time/money

362

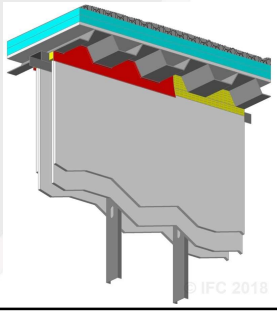
Joint: Rated wall to non-rated floor or roof

- ASTM E2837-11:
  Standard Test Method for Determining the Fire Resistance of Continuity Head-of-Wall Joint Systems Installed Between Rated Wall Assemblies and Nonrated Horizontal Assemblies
- UL listing category XHBO
  - Nomenclature, e.g. CJ-D-0001

363

ASTM E2837 listings

- Many for insulated steel deck roof
- No modifications ever needed to roof or wall
- Typical "stuff and spray" joint systems similar to E1966/UL2079 listings

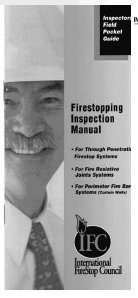


364

Available Resources

- Product Information - manufacturer's websites
- International Firestop Council (IFC) - www.firestop.org
- Firestop Contractors International Association (FCIA) -www.fcia.org

- IFC pocket Firestopping Inspection Manual
- IFC Inspection Guidelines for Through-Penetration and Fire Resistive Joint Systems in Fire Resistance Rated Construction



365

Additional firestop training

- IFC offers:
  - Free 1.5 to 8 hour educational seminars for AHJs
  - Free Online special inspector training program www.firestop.org/inspection
  - 1-day hands-on training seminar for special inspectors (inspect to ASTM E2174/E2393)
- Contact info@firestop.org to request training seminar

ICC PREFERRED PROVIDER PROGRAM

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Would you like to help shape Codes and Standards?

- For assistance with passive fire protection issues feel free to contact the International Firestop Council
- Please call or e-mail the IFC Technical Director
  - 918-200-3757
  - JohnV@firestop.org

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Available Resources

- International Firestop Council (IFC)
  www.firestop.org
- Firestop Contractors International Association
  www.fcia.org
  Free webinars
  Free magazine "Life Safety Digest" (request from info@fcia.org)
- Fire Safe North America
  www.firesafenorthamerica.org
- ASTM International standards
  www.astm.org

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Available self-education documents on IFC website include.....

www.firestop.org

- Firestop 101 – An introduction to firestopping
- Perimeter Curtain Wall Fire Protection
- Firestop System Selection
- Flexible Duct Wrap Systems
- Fire Protection of Construction Joints

Videos: International Firestop Council Channel on YouTube

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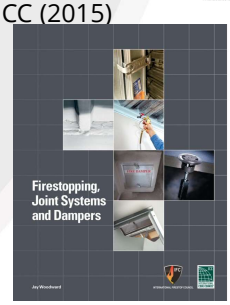
Further your knowledge of firestopping and codes:
Reference book published by ICC (2015)

- http://www.firestop.org/online-store
- http://shop.iccsafe.org/firestopping-joint-systems-and-dampers-1.html



370

If not already completed....

- Please take our seminar feedback survey:

Paper copy
or
https://www.surveymonkey.com/r/FirestopSeminar
(only 3-4 mins!)

You can scan the QR code to take you to the survey

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THANK YOU FROM THE IFC

The International Firestop Council(IFC) is a not-for-profit association of manufacturers and industry partners of fire protective materials and systems.

IFC's mission is to promote the technology of fire containment in modern building construction through research, education and development of safety standards and code provisions.

Website - www.firestop.org

Email - Info@firestop.org

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File Attachments for Item:

EC-12 Surfside, Florida Building Collapse and ACI 318 Requirements for Structural Concrete (ICC)

All certifications (4 hours)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Laura Morris

Organization: International Code Council

Address: 4051 Flossmoor Rd., Country Club Hills, IL 60478

E-mail: lmorris@iccsafe.org Telephone: 888-422-7233 Ext: 4523

Website: iccsafe.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete

Course instructor: Dr. S. K. Ghosh

Course description: This seminar focuses on three main areas of improvement in the ACI standard for concrete design and construction and indicates how compliance with the enhanced requirements would have been beneficial to the performance of Champlain Tower South in Surfside, Fl. The ~~12-story condominium building, where 98 people were killed, was likely designed under the early or mid-1970s Florida Building~~ Code and ACI 318-71 or ACI 318-77. Concrete durability, flat plate punching shear and structural integrity provisions of ACI 318 are critical areas of improvement that engineers, architects, and building officials must be familiar with for the safe performance of concrete buildings.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: May 1, 2023 Tampa, FL

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online?_____ **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X_____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

x Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete

Description

This seminar focuses on three main areas of improvement in the ACI standard for concrete design and construction and indicates how compliance with the enhanced requirements would have been beneficial to the performance of Champlain Tower South in Surfside, Fl. The 12-story condominium building, where 98 people were killed, was likely designed under the early or mid-1970s Florida Building Code and ACI 318-71 or ACI 318-77. Concrete durability, flat plate punching shear and structural integrity provisions of ACI 318 are critical areas of improvement that engineers, architects, and building officials must be familiar with for the safe performance of concrete buildings.

Learning Objectives

1. Get a detailed overview and delve and the causes that led to the catastrophic Surfside Miami collapse.
2. Learn about the role of concrete durability in the collapse and how the ACI requirements have changed for concrete durability over the years.
3. Learn about the role of structural integrity which was one of the causes of the collapse and how the ACI requirements have changed regarding to structural integrity over the years.
4. Learn about punching shear that was an evident form of failure in the Surfside collapse.

Outline of Seminar **(4 hours = 240 minutes)**

8:00 AM – 12:00 PM

I. Part I General Overview of Surfside Collapse and its possible causes (60 minutes)

   I. Overview of the Surfside Building collapse
   II. Possible causes of partial collapse
   III. Critical improvements in ACI 318 since building was designed.
   IV. Discussion

II. Part II ACI 318 Durability Requirements. (60 minutes)

I. Concrete durability requirements prior to ACI 318-08
II. Concrete durability requirements from ACI 318-08 to 318-19
III. Durability of reinforcement
IV. Discussion

III. Part III ACI 318 Structural Integrity Requirements (60 minutes)
I. Structural integrity, progressive collapse
II. Cast-in-place joists and beams
III. Nonprestressed two-way slabs
IV. Post tensioned two-way slabs
V. Precast concrete construction
VI. Discussion

IV. Part IV ACI 318 Requirements for Flat-Plate Column Frames (60 minutes)
I. Definitions
II. Design of two-way column-supported slabs
III. Punching shear at slab-column joints
IV. Unbalanced moment transfer at slab-column joints
V. Discussion

Please allow for breaks at natural intervals

Instructor Bio: Dr. S.K. Ghosh, PhD

Dr. Ghosh is a former member of the Boards of Direction of ACI, the Earthquake Engineering Research Institute (EERI) and BSSC (Building Seismic Safety Council). He is a member of the Board of Governors of ASCE's Structural Engineering Institute. Ghosh has long been a provider of continuing education related to structural provisions of building codes to the structural engineering profession and the code enforcement community. His books and other publications on structural design are widely used by those in design practice. In addition to authoring over 200 papers and books, Dr. Ghosh has investigated and reported on structural performance in most recent earthquakes. Among his many awards, on the 50th anniversary of the Precast/Prestressed Concrete Institute (PCI) in 2004, S. K. Ghosh was named one of fifty "Titans" of the U.S. Precast/Prestressed Concrete Industry. He was awarded ASCE's 2013 Walter P. Moore Jr. Award for his contributions towards improving the consistency, accuracy and clarity of structural codes and standards throughout the U.S. and abroad. Ghosh has a Bachelor of Engineering (BE) in civil engineering from the University of Calcutta, India, and a Master of Applied Science (MASc) and Doctor of Philosophy (Ph.D.) in structural engineering from the University of Waterloo, Ontario, Canada.

Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete: Part 1 of 4

S. K. Ghosh, S. K. Ghosh Associates LLC

Palatine, IL

The Event

On **Thursday, June 24, 2021**, at approximately 1:25 a.m. EDT, Champlain Towers South, a 12-story beachfront condominium in the Miami suburb of Surfside, Florida, partially collapsed. Ninety-eight people died.

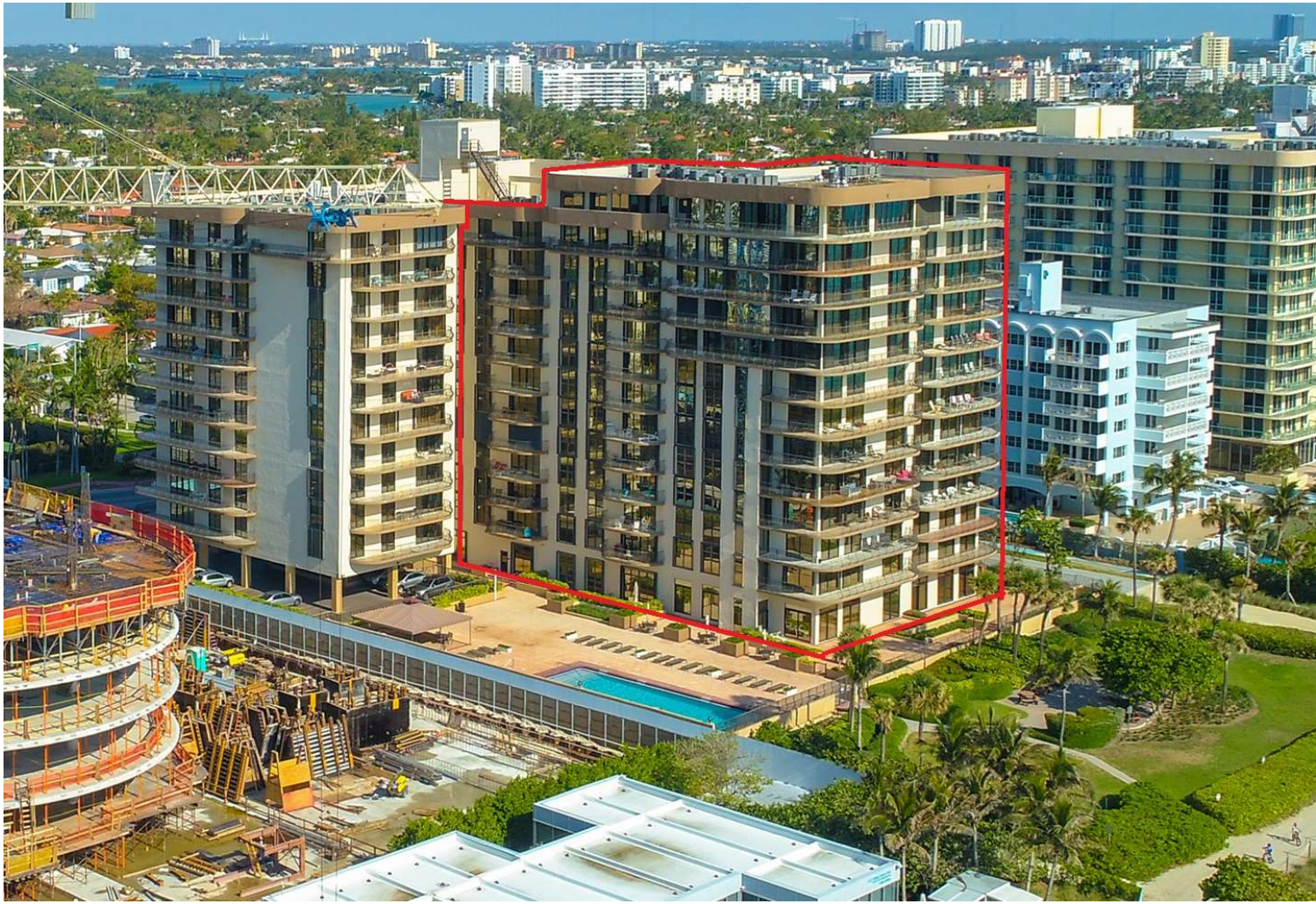
The Event

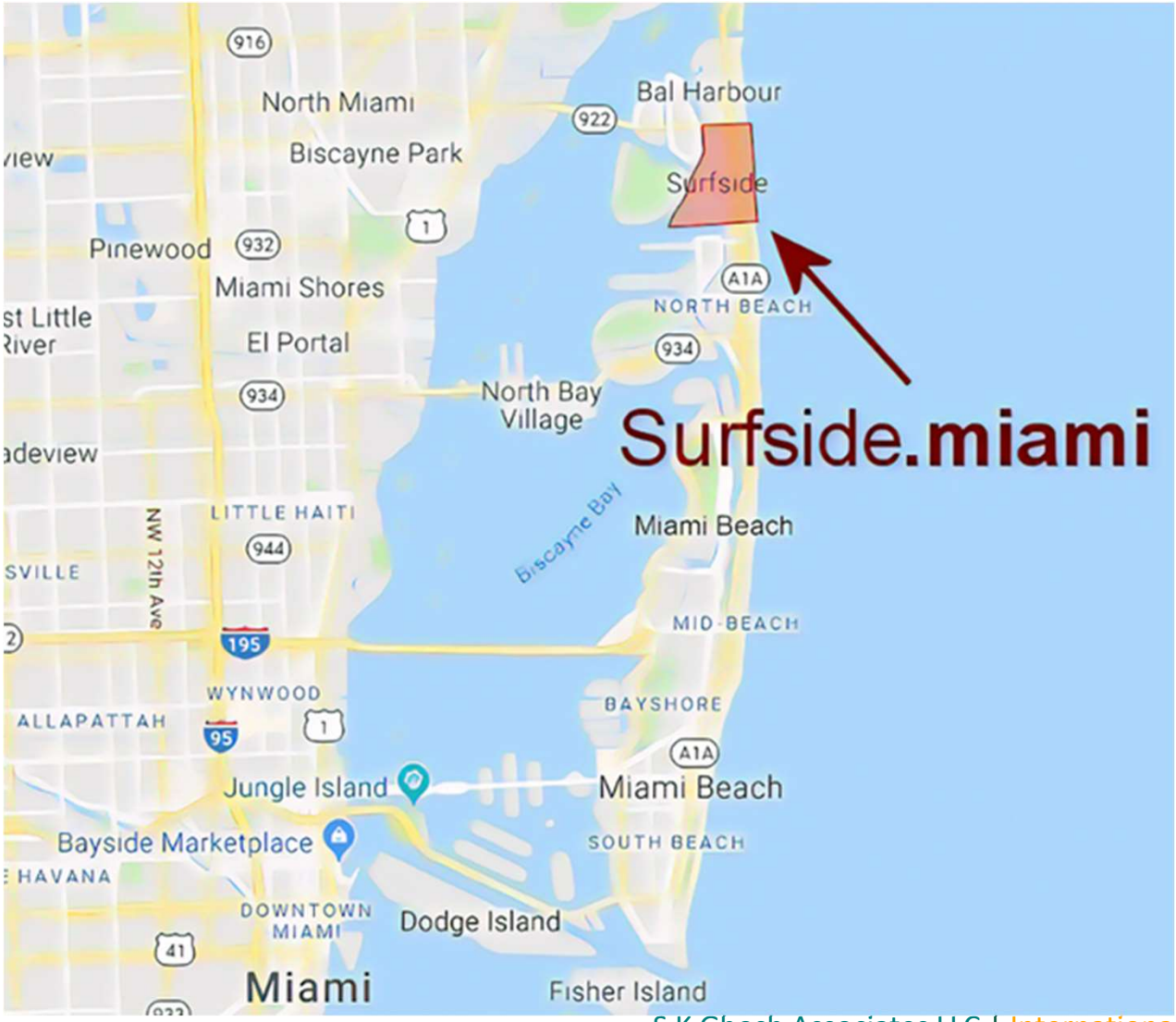
The collapse of Champlain Towers South was unprecedented. The tower wasn't particularly old or under major construction. There was no earthquake, gas explosion or terrorist attack to blame.

After standing for nearly four decades, the building simply caved in — for no obvious reason.

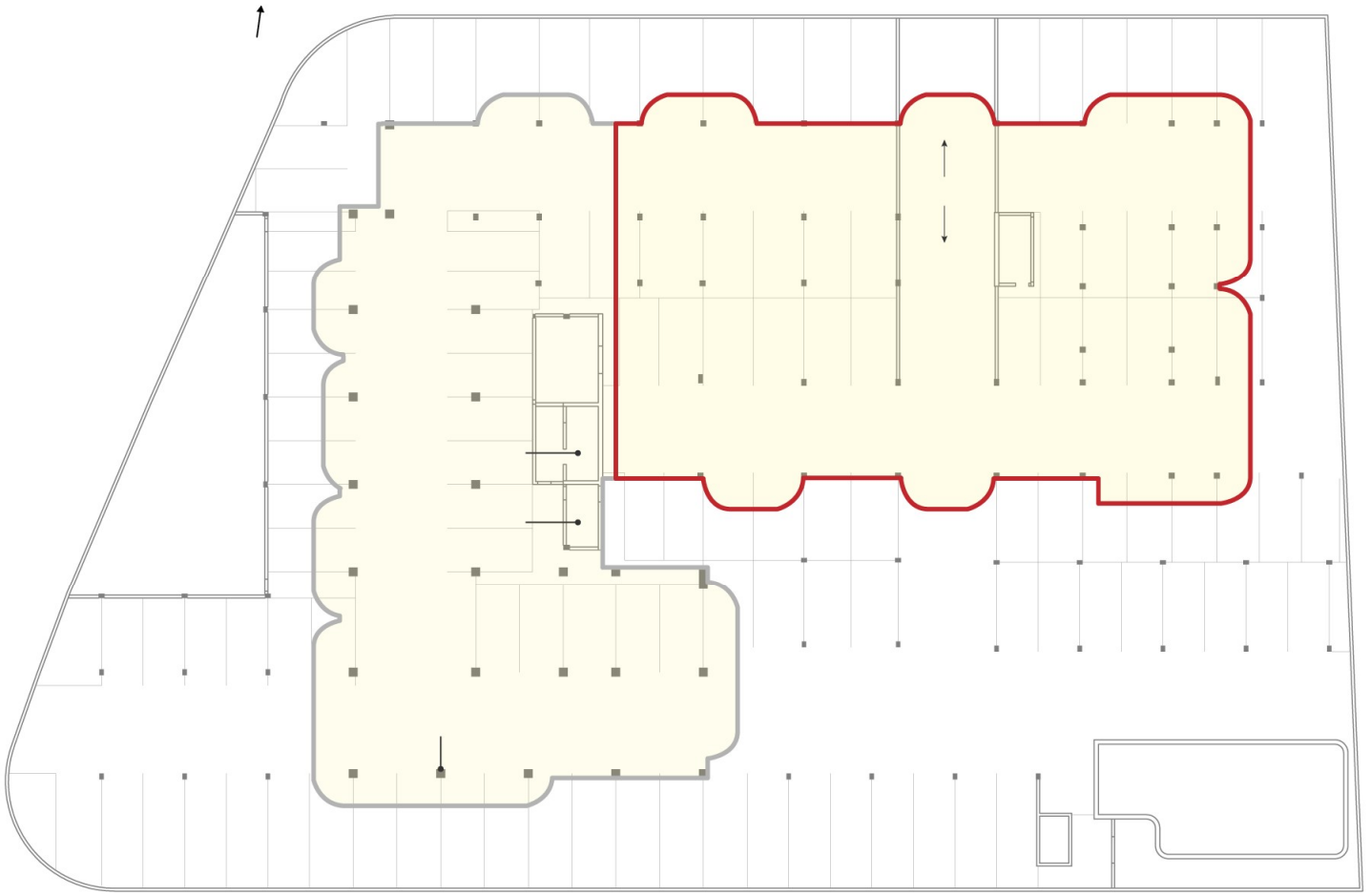
… Miami Herald

Champlain Tower South Before Collapse



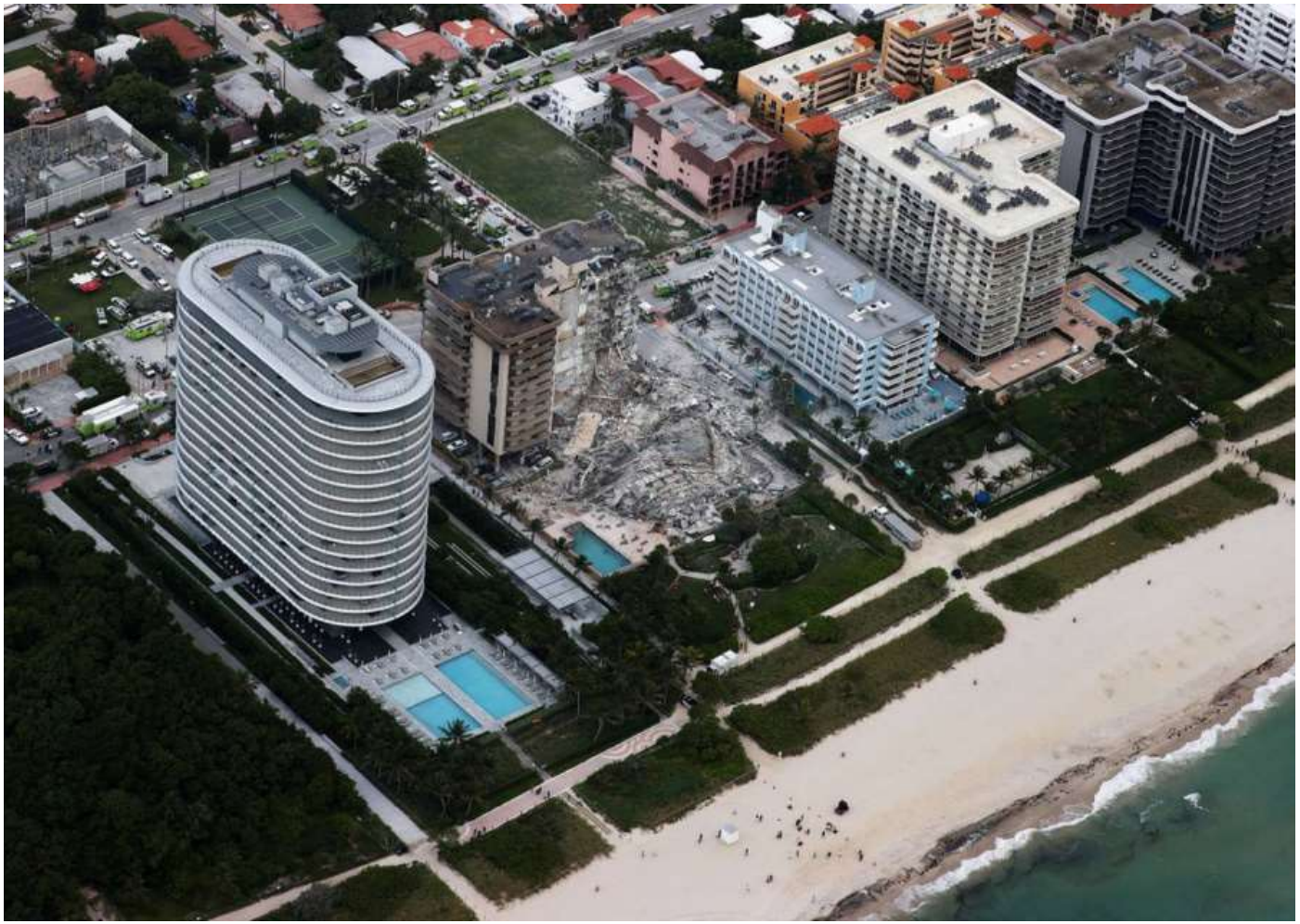

North Miami
Biscayne Park
Bal Harbour
Surfside
Pinewood
Miami Shores
El Portal
North Bay Village
NORTH BEACH
Surfside.miami
LITTLE HAITI
Miami Beach
Biscayne Bay
MID-BEACH
WYNWOOD
ALLAPATTAH
BAYSHORE
Jungle Island
Miami Beach
Bayside Marketplace
SOUTH BEACH
DOWNTOWN MIAMI
Dodge Island
Miami
Fisher Island
NW 12th Ave
916
922
932
934
944
195
95
1
41
A1A

Plan of the Building (NY Times)



Orientation of the Three Towers

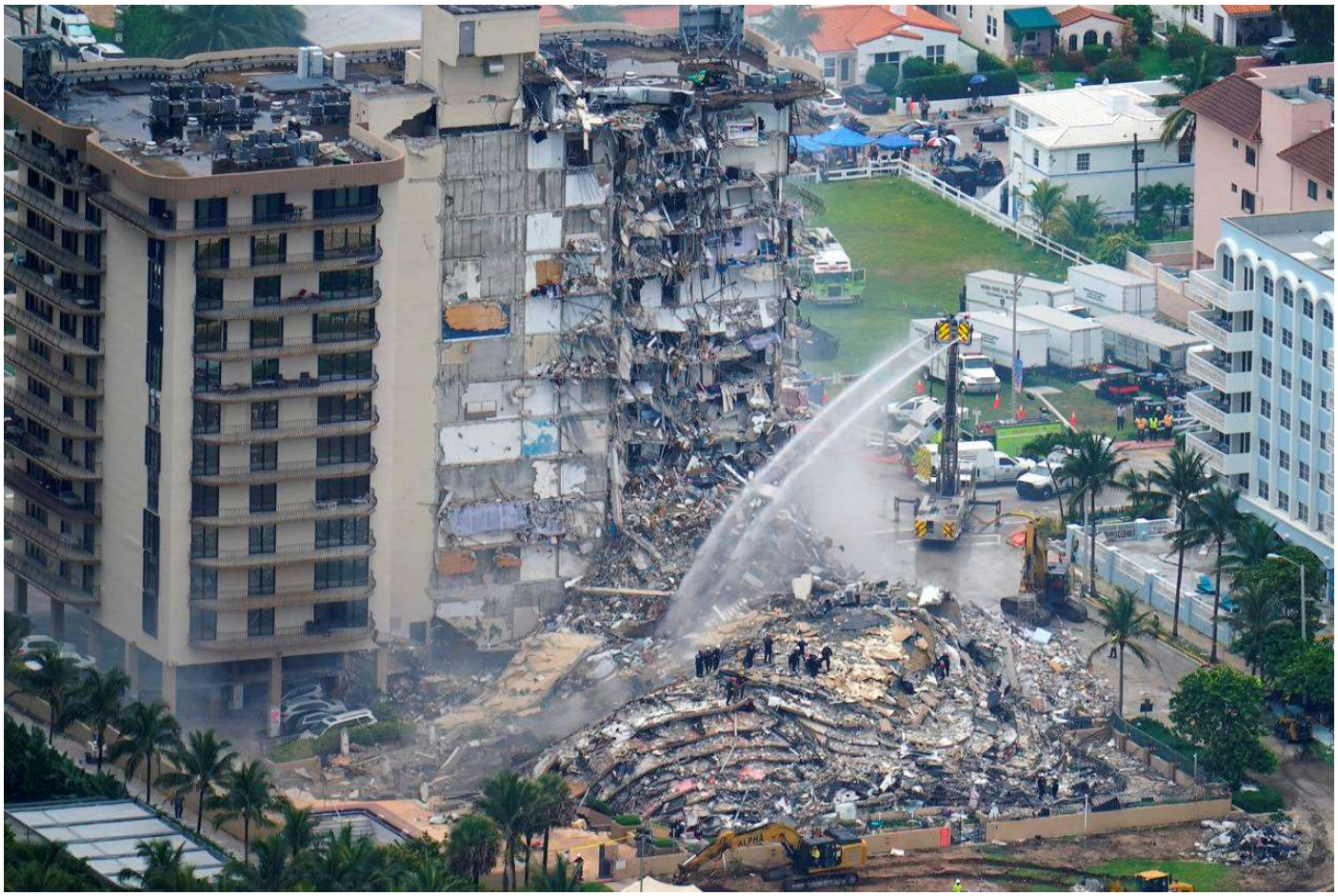
Collapsed Orientation of Champlain Tower South



Collapse View from the Ocean Side (East)

Collapse View from the Ocean Side (East)

Collapse View from South East

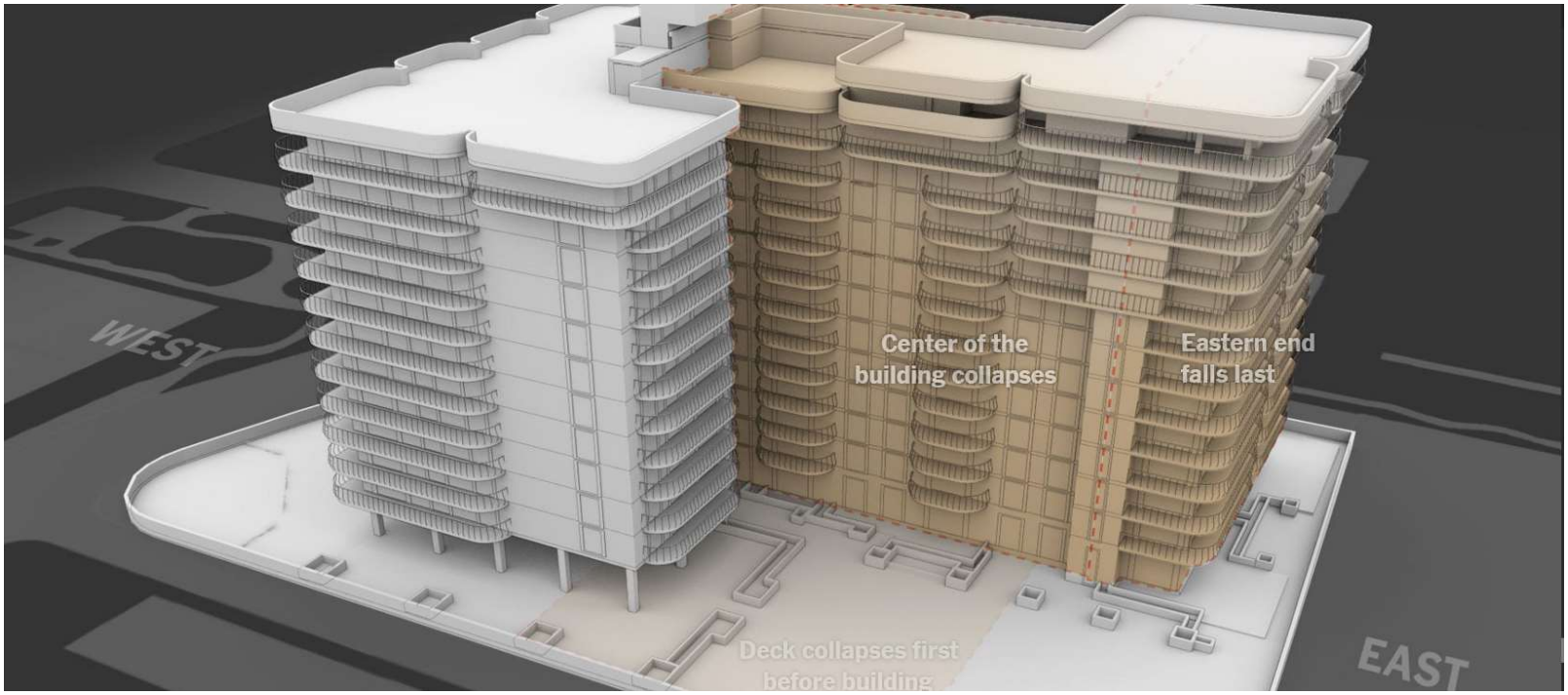


Aerial View of the Collapse

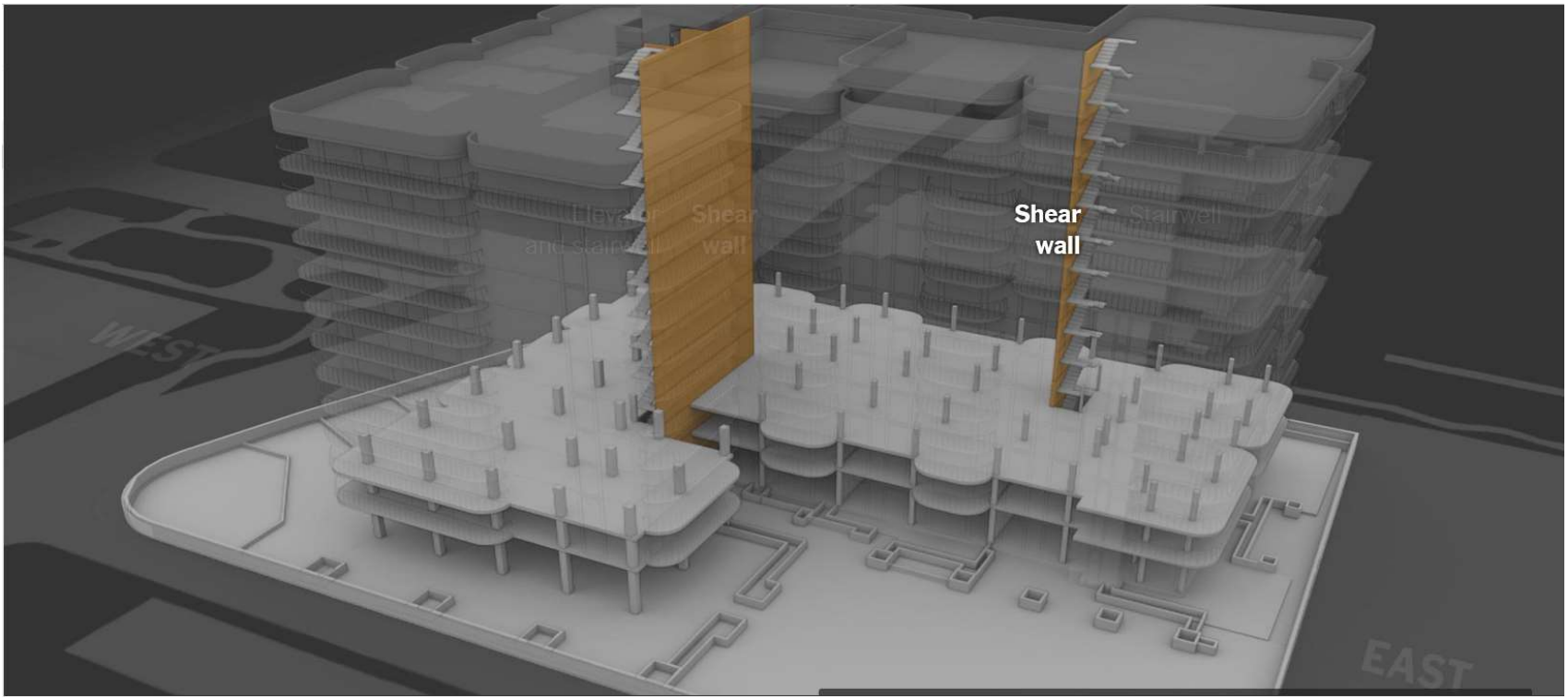
Aerial View of the Current State

Before and After Collapse

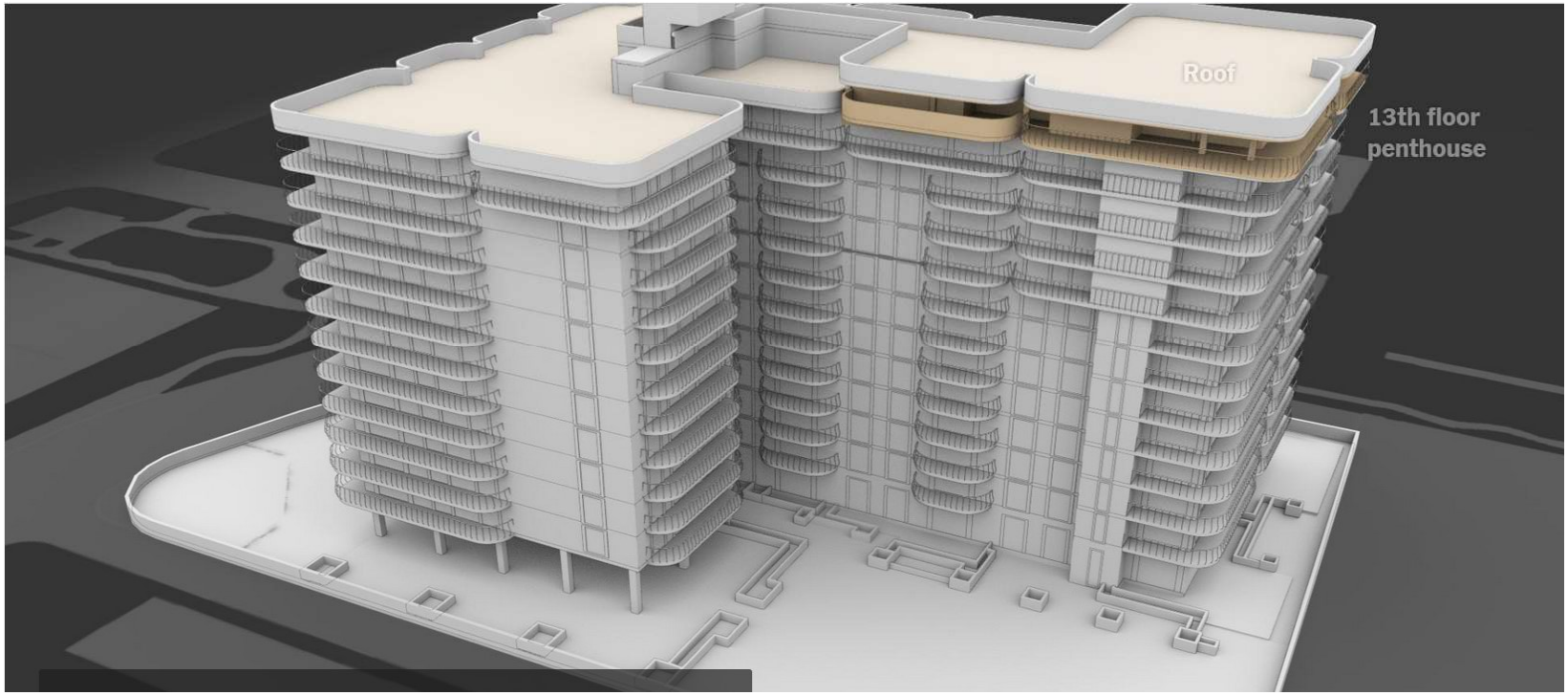
Portions of Building That Collapsed



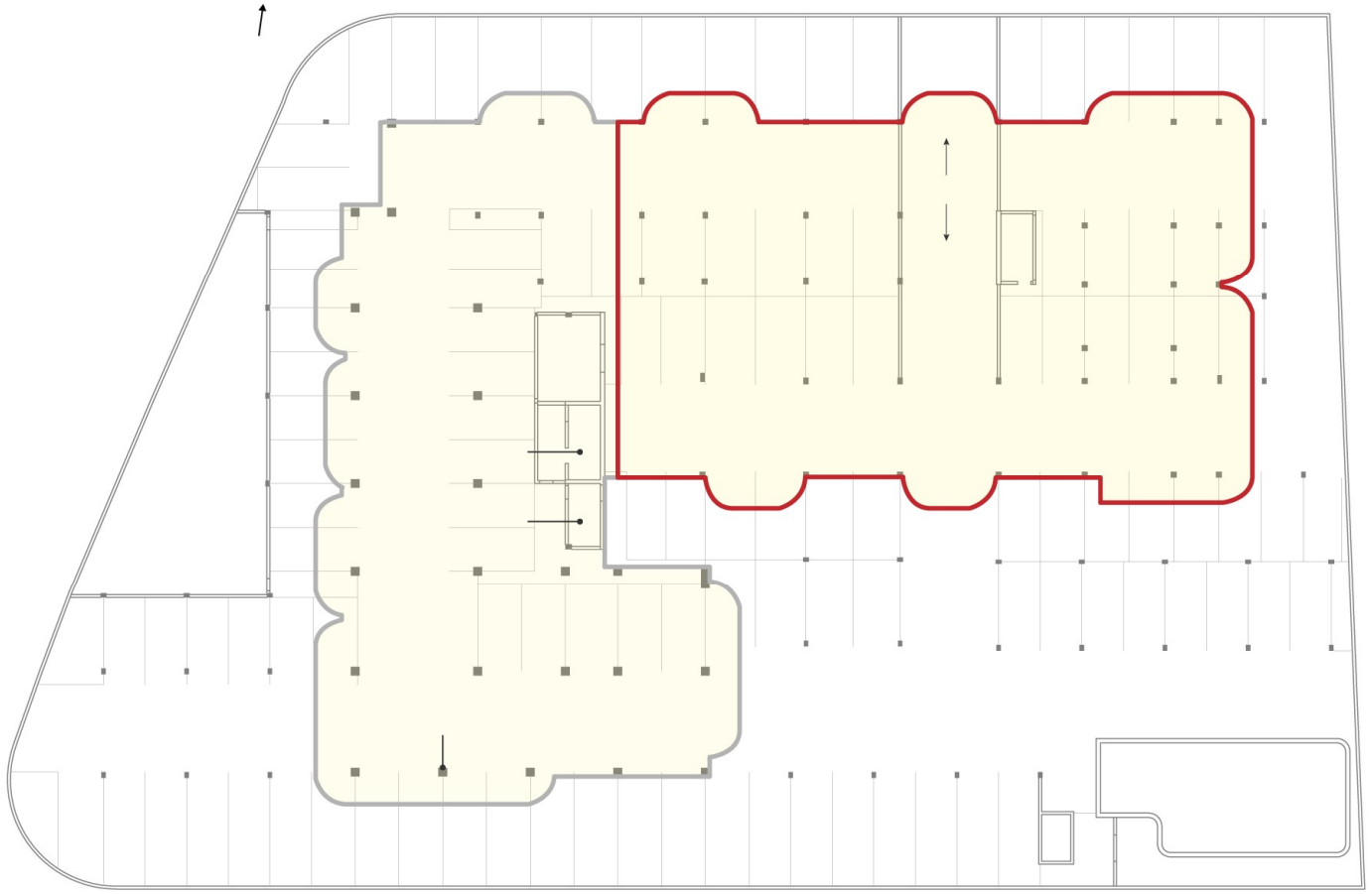
Shear Walls in High-Rise Portions of Building



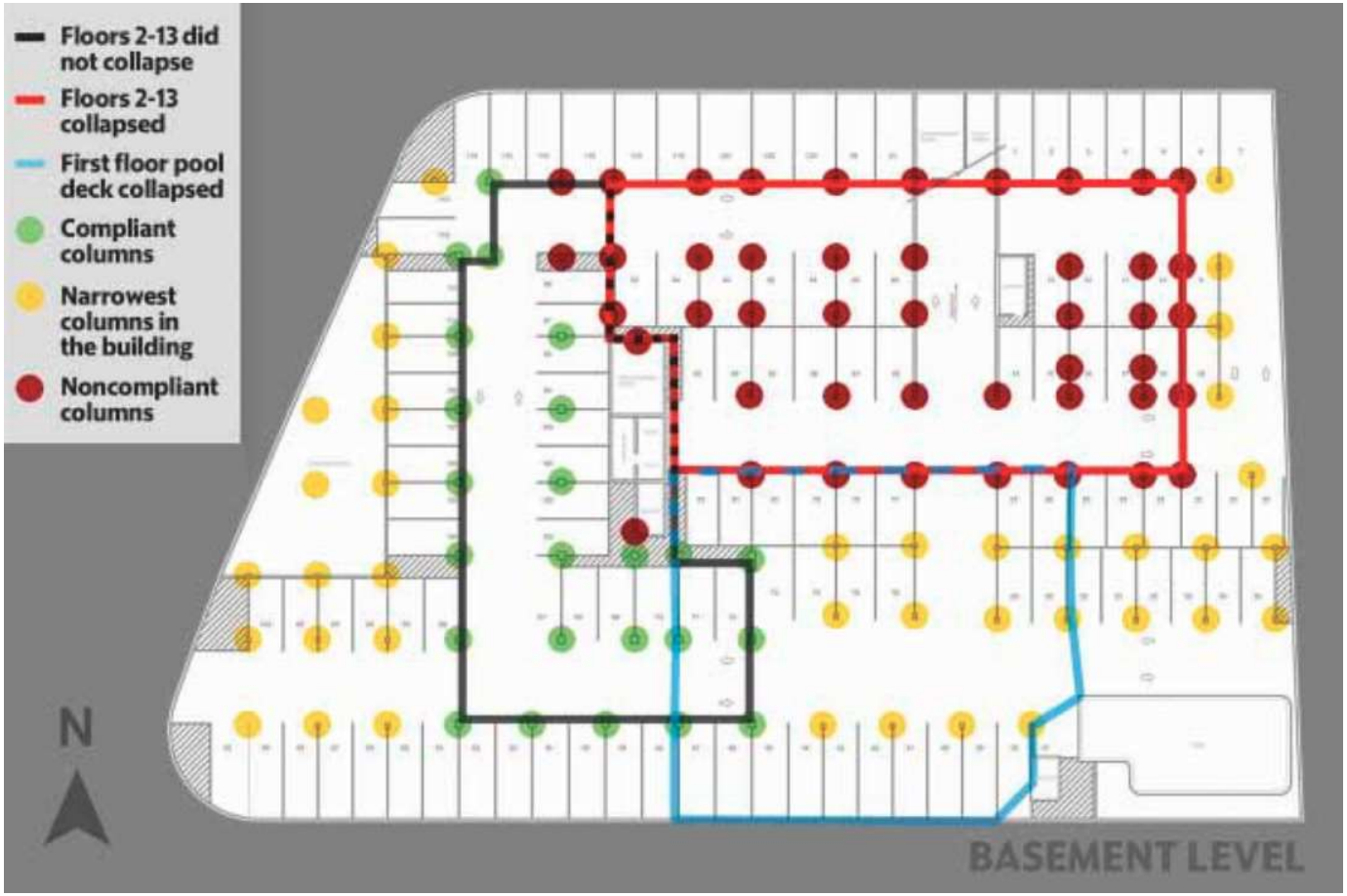
“Questionable” Partial 13th Story Penthouse



Plan of the Building (NY Times)



Plan of the Building (Miami Herald)



Punching Shear Failure of Parking Structure Slab

Punching Shear Failure of Parking Structure Slab

(PHOTO BY SAUL MARTINEZ FOR THE WASHINGTON POST)

The standing columns here suggest the columns “punched through” the deck.

First Indication of Failure

In the months since the collapse on June 24, the Miami Herald reconstructed the event through the eyes of 10 key witnesses … .

Guided by what each person saw, what they didn't see, and especially what they heard, the Herald worked with engineering professor Dawn Lehman from the University of Washington to identify where the collapse could have started, and how it spread to become one of the deadliest building failures in modern history.

First Indication of Failure

Lehman said the witnesses' collective memory, along with computer models informed by the building's history and damage observed after the tragedy, suggest that the collapse likely began when corroded steel reinforcement fractured in the first-floor slab, at or near the southern edge of the pool deck.

S K Ghosh Associates LLC | International Code Council

First Indication of Failure

Whatever made the first, distinct booming noises wasn't big, or obvious or dusty — so, probably, it was not a large chunk of concrete falling from the pool deck into the garage below, Lehman said.

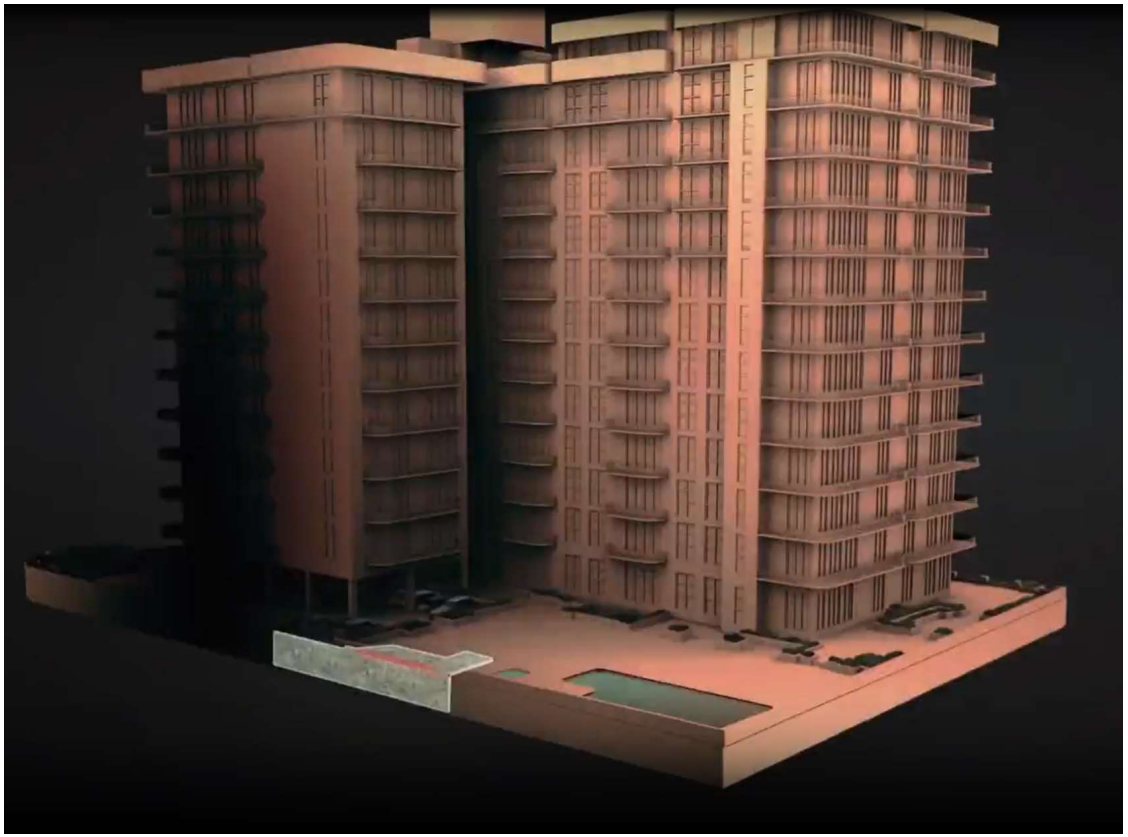
She began to look for a less obvious starting point.

"Something that makes sound but you can't see is almost always reinforcement — rebar — failing [inside the concrete]," Lehman said.

Pool Deck Slab at South Wall

Miami Herald

Pool Deck Slab at South Wall



Miami Herald

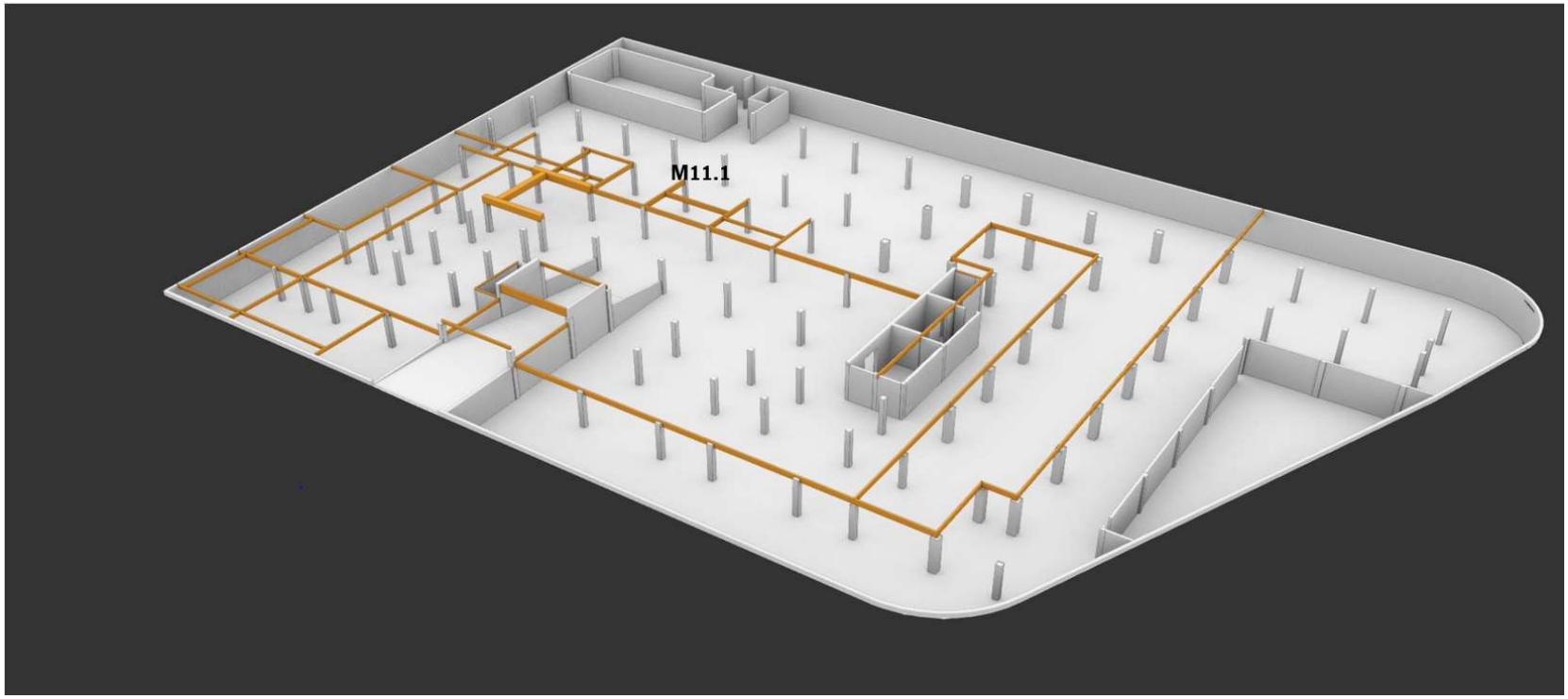
Pool Deck Slab at South Wall

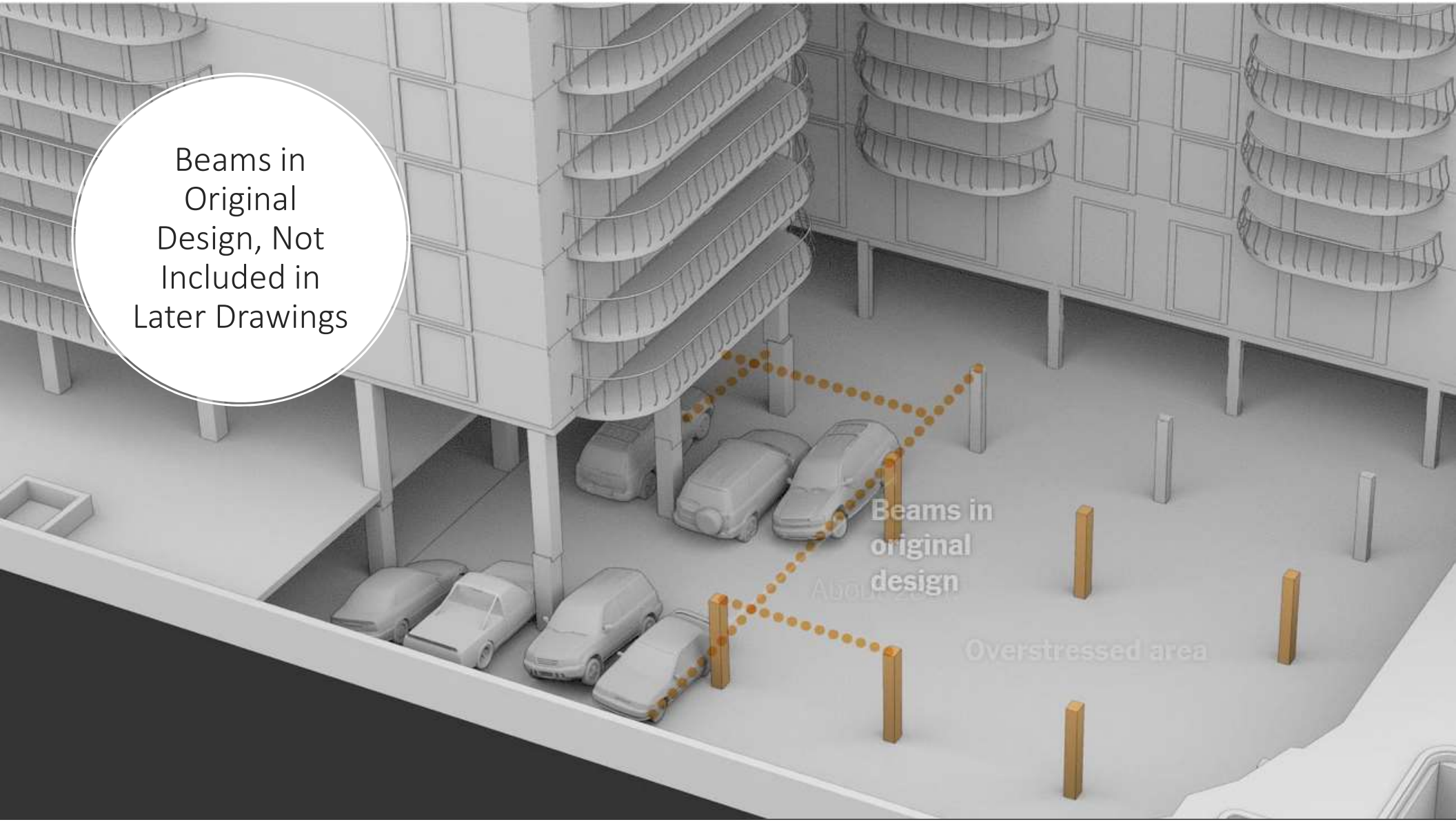
Miami Herald

Pool Deck Slab at South Wall

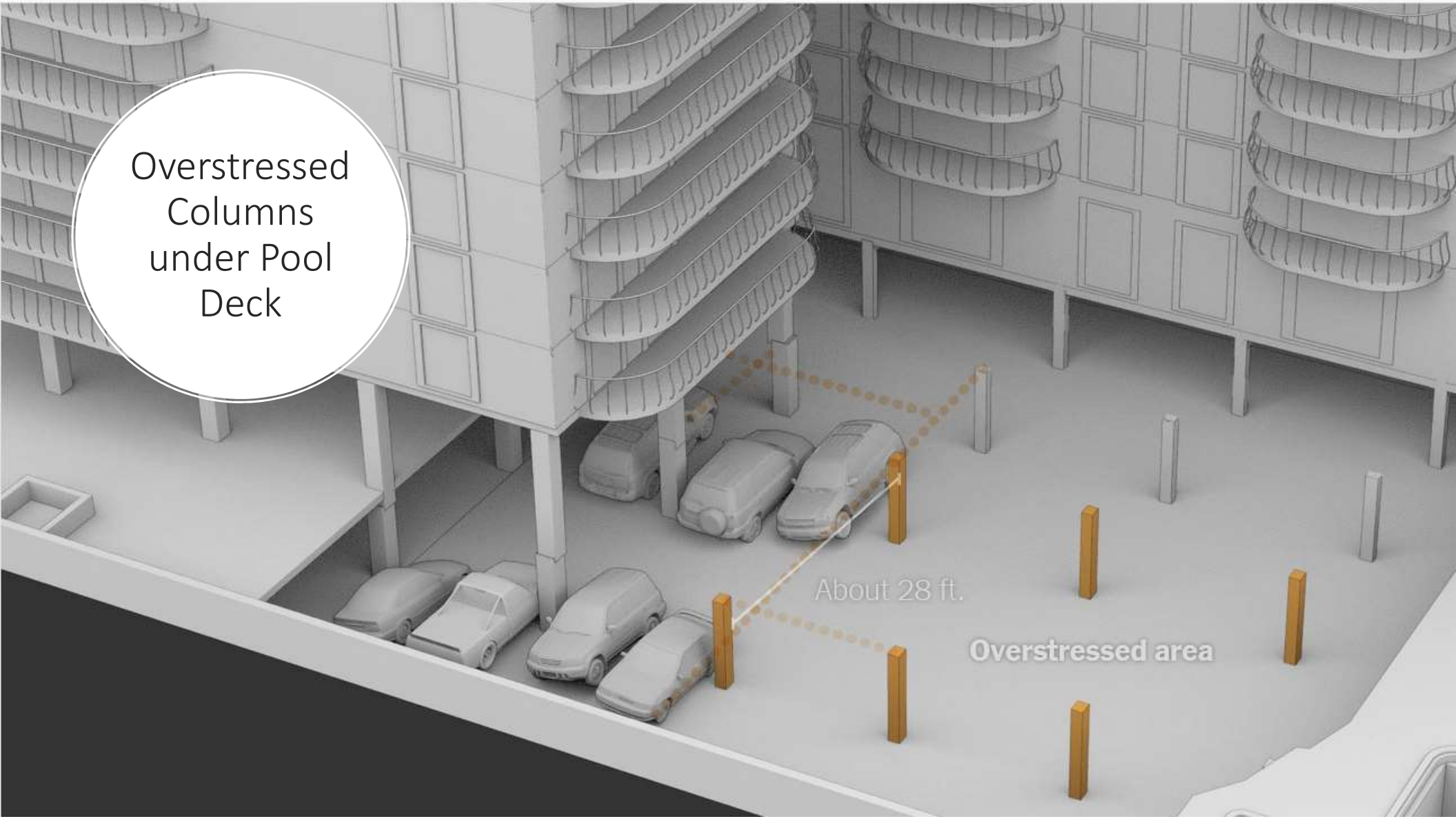
Miami Herald

Beams Supporting Ground-Level Slab above Basement

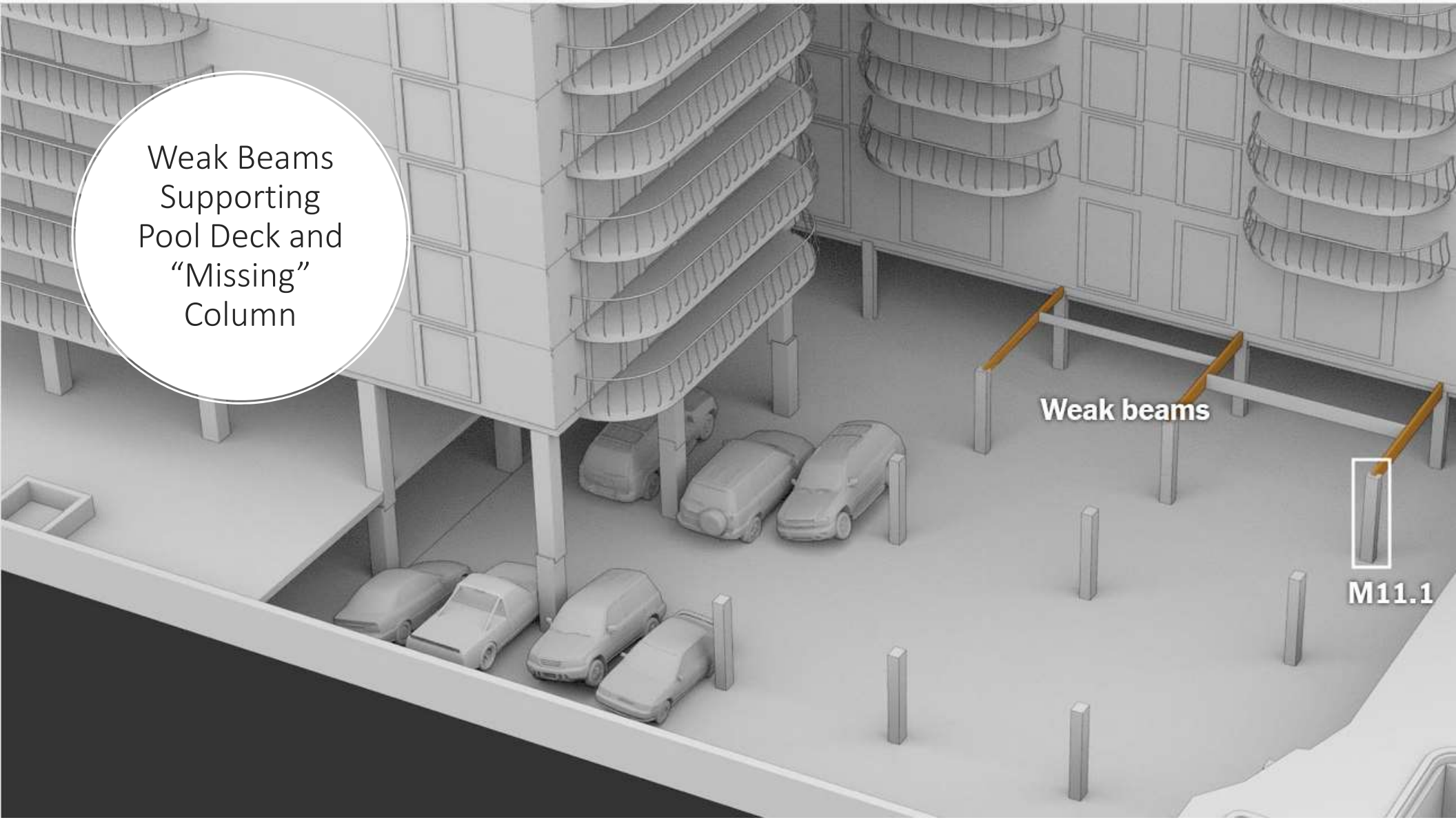



Beams in Original Design, Not Included in Later Drawings
Beams in original design
Overstressed area

Overstressed Columns under Pool Deck



Weak Beams Supporting Pool Deck and "Missing" Column



Pool Deck Slab Punched through Supporting Columns

Possible Destabilized Columns Where Partial Collapse Started

Report by Morabito Consultants dated October 8, 2018

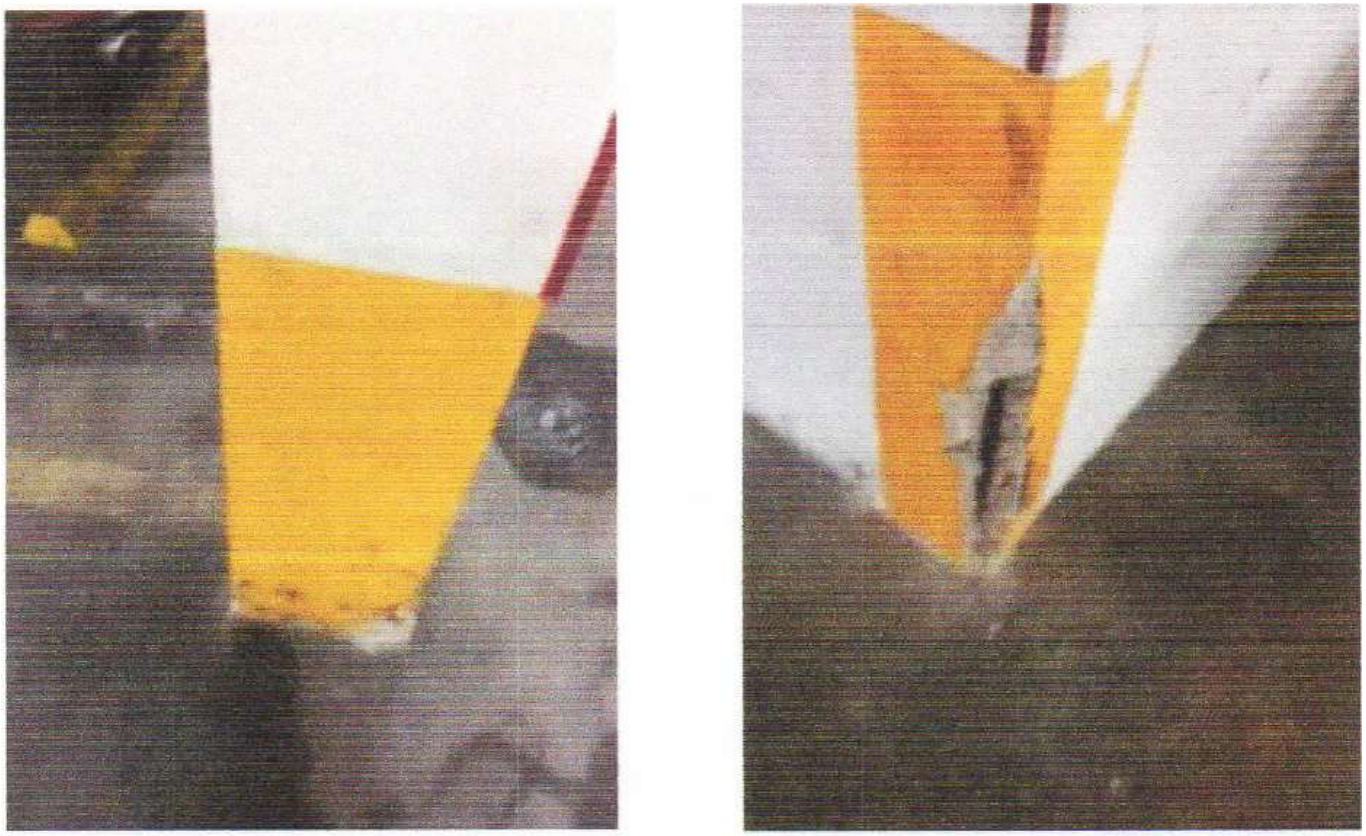
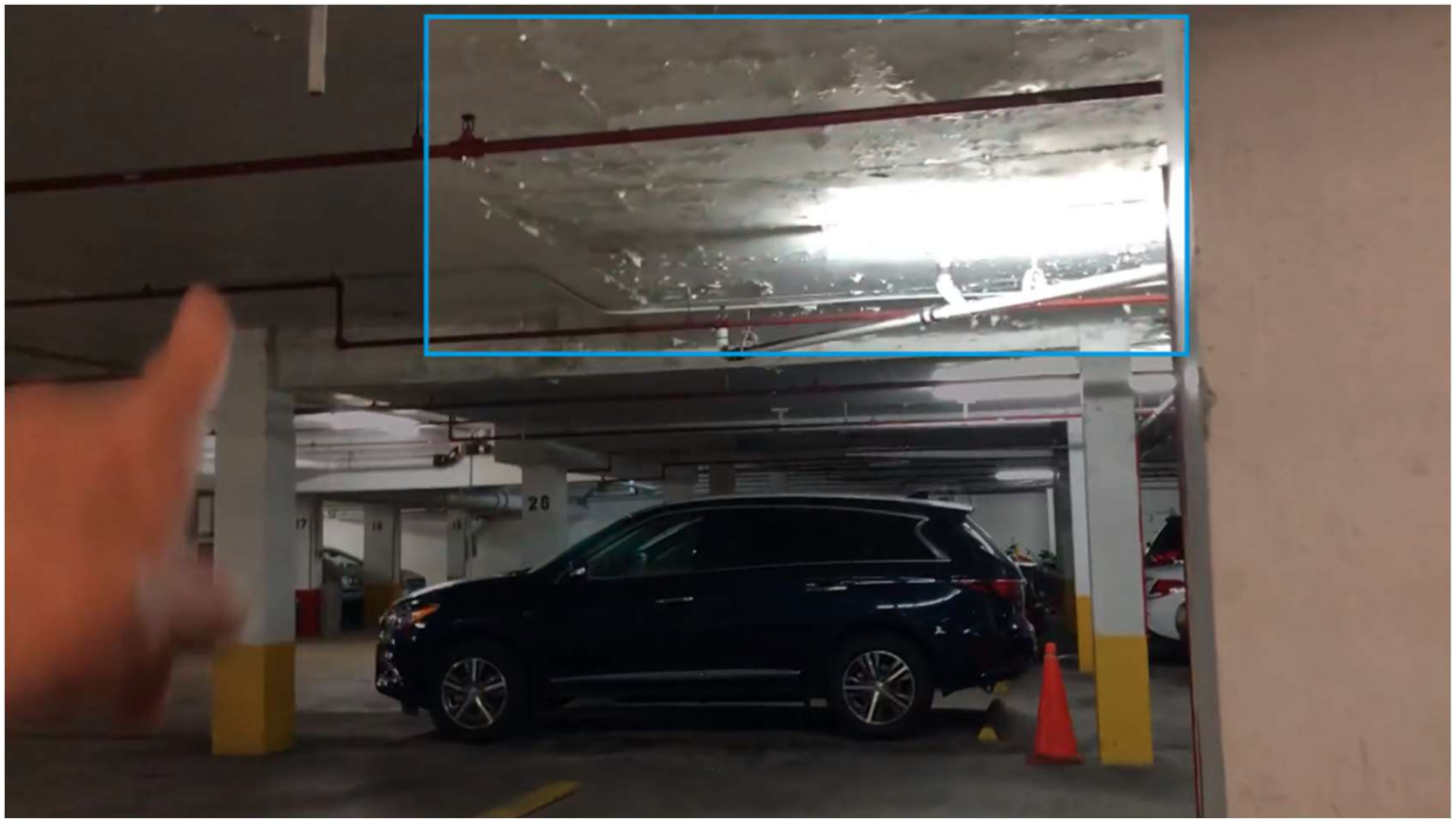
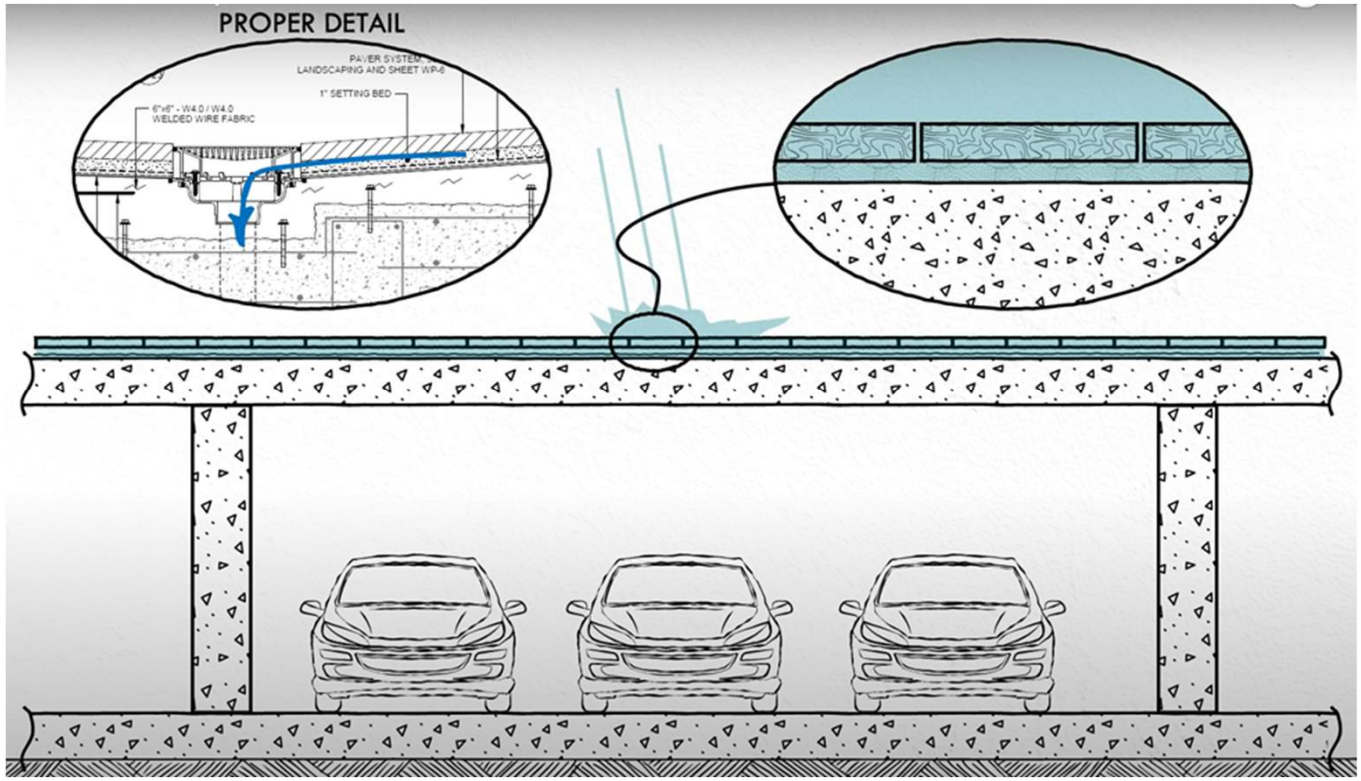


Figure J1: Typical cracking and spalling at parking garage columns

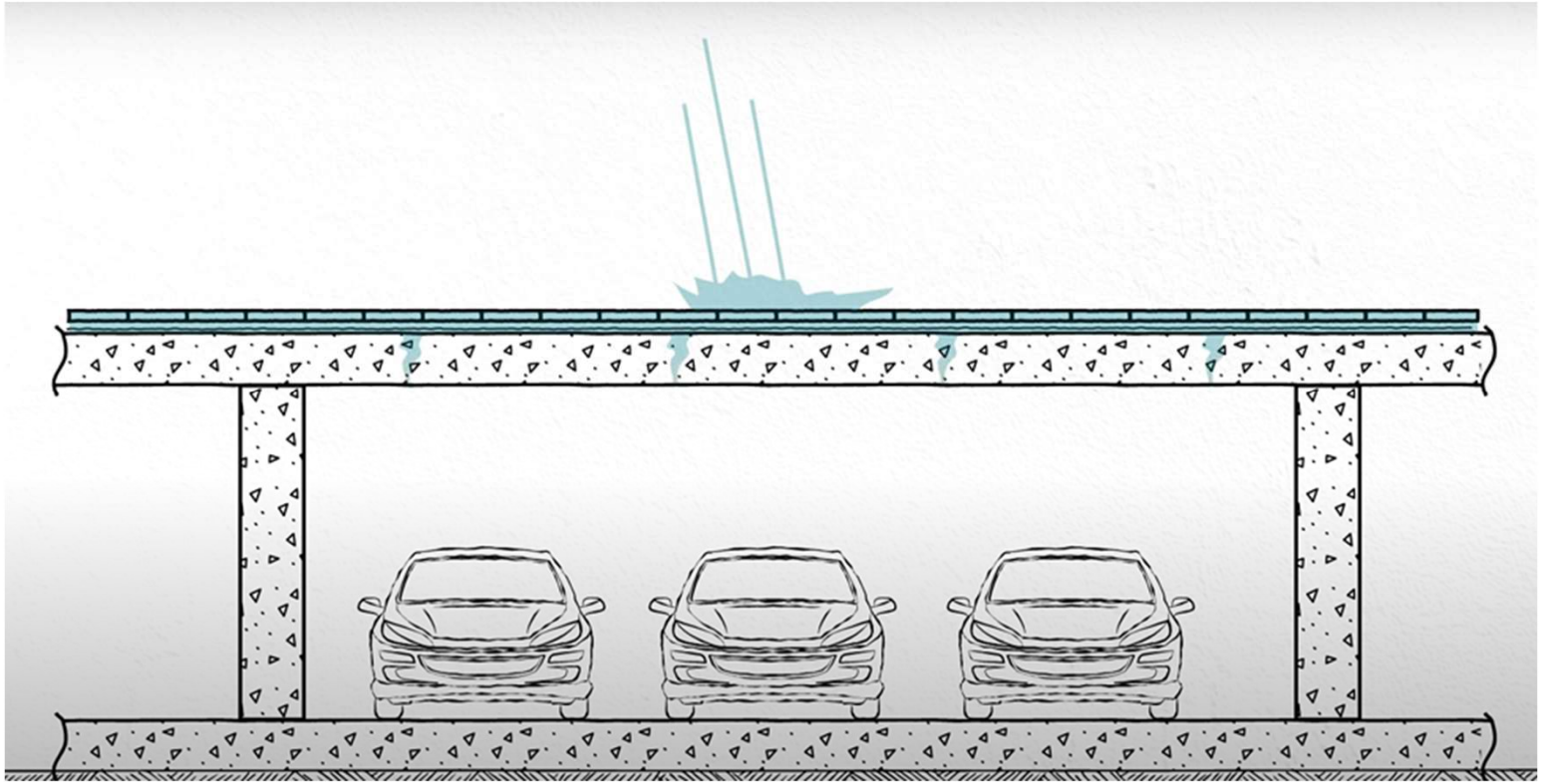
Deterioration of Parking Structure Slab due to Water Seepage



Deterioration of Parking Structure Slab due to Water Seepage (Illustration)

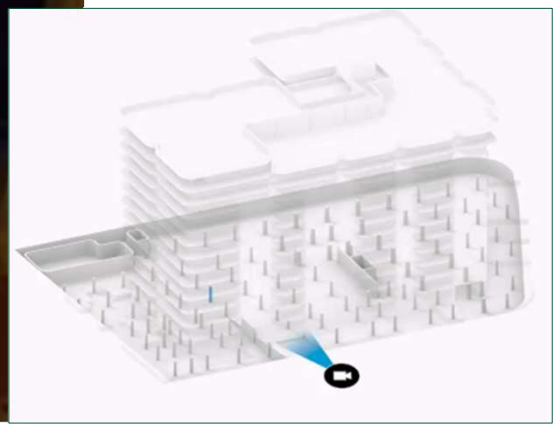


Deterioration of Parking Structure Slab due to Water Seepage (Illustration)



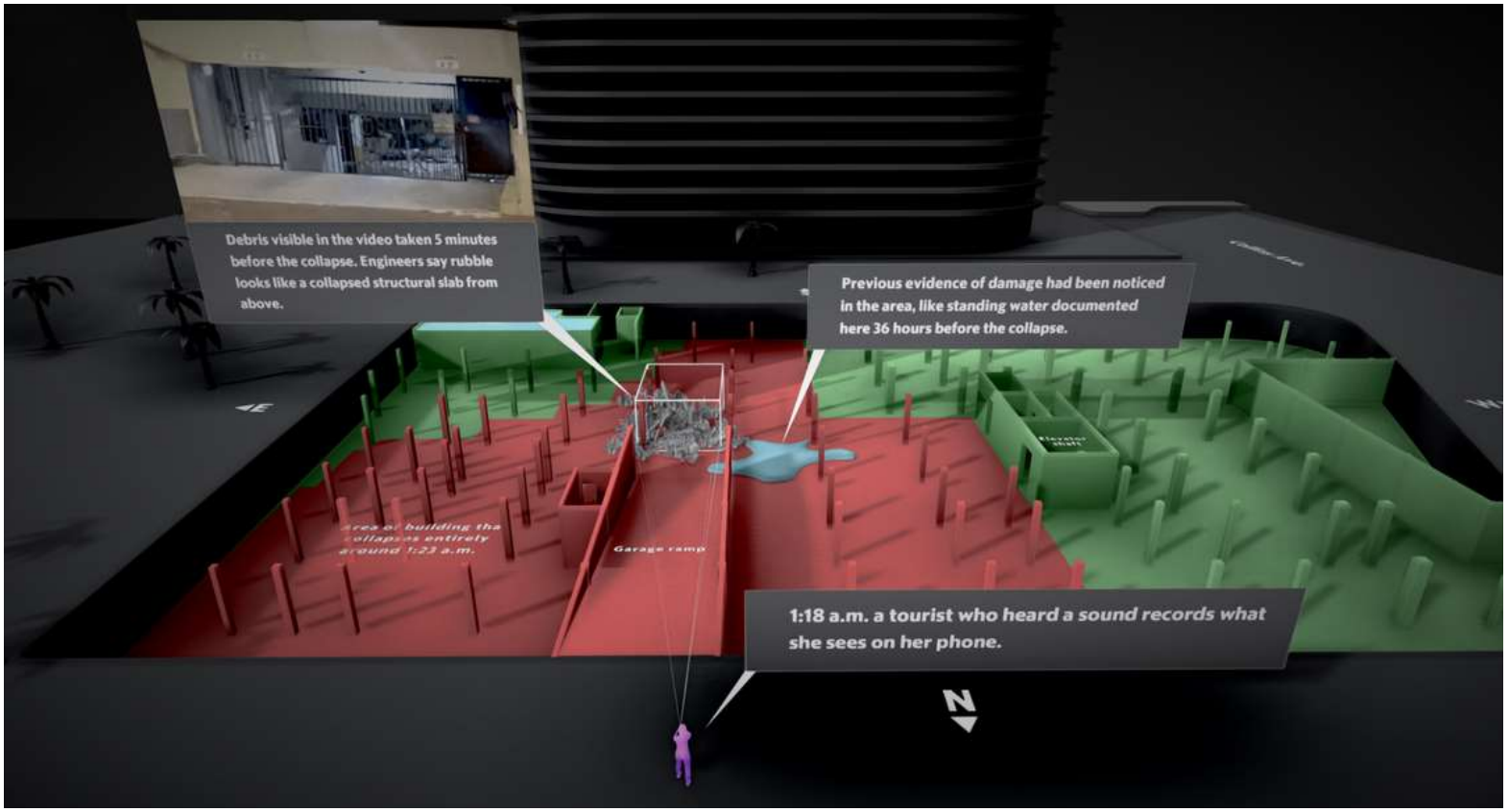
Water Leakage From Ceiling of Garage

This water leakage was recorded right before the collapse. The water and fallen debris appear to have been roughly below the planter beds on the pool deck's northern edge.



LEFT: Adriana Sarmiento via Storyful, Right: The Washington Post

Five Minutes Before Collapse



S K Ghosh Associates LLC | International Code Council

Possible Causes of Partial Collapse

- Code violations
- Improper design
- Improper construction
- Inadequate maintenance
- Failure to heed calls for repair from competent professionals
- Combinations of some or all of the above

Possible Causes of Partial Collapse

(Prof. Atorod Azizinamini, Florida Atlantic University)

1. Detail in column strip for bottom reinforcement probably met the code requirement (1971) but does not meet current code requirement for structural integrity
2. Foundation did not include grade beams and allowed uneven settlement. Shear walls in east west direction was very minimal. In North South direction, poor judgment was exercised in proportioning the shear wall.
3. Slab at pool level was tied to building and expansion joint was not provided.
4. It is not clear how slab at garage level was connected to column. Is it at foundation level? Is it about two ft above foundation?
5. The reinforcement ratio for columns are crazy (more than 6 percent). This means at splice location you would have 12 percent steel.

Critical Improvements in ACI 318 since Building Was Designed

The building was likely designed under the early or mid-1970s Florida Building Code and ACI 318-71 or ACI 318-77. Concrete durability, flat plate punching shear, and structural integrity provisions of ACI 318 are critical areas of improvements that engineers, architects, and building officials must be familiar with for safe performance of concrete buildings.

Thank you for participating!

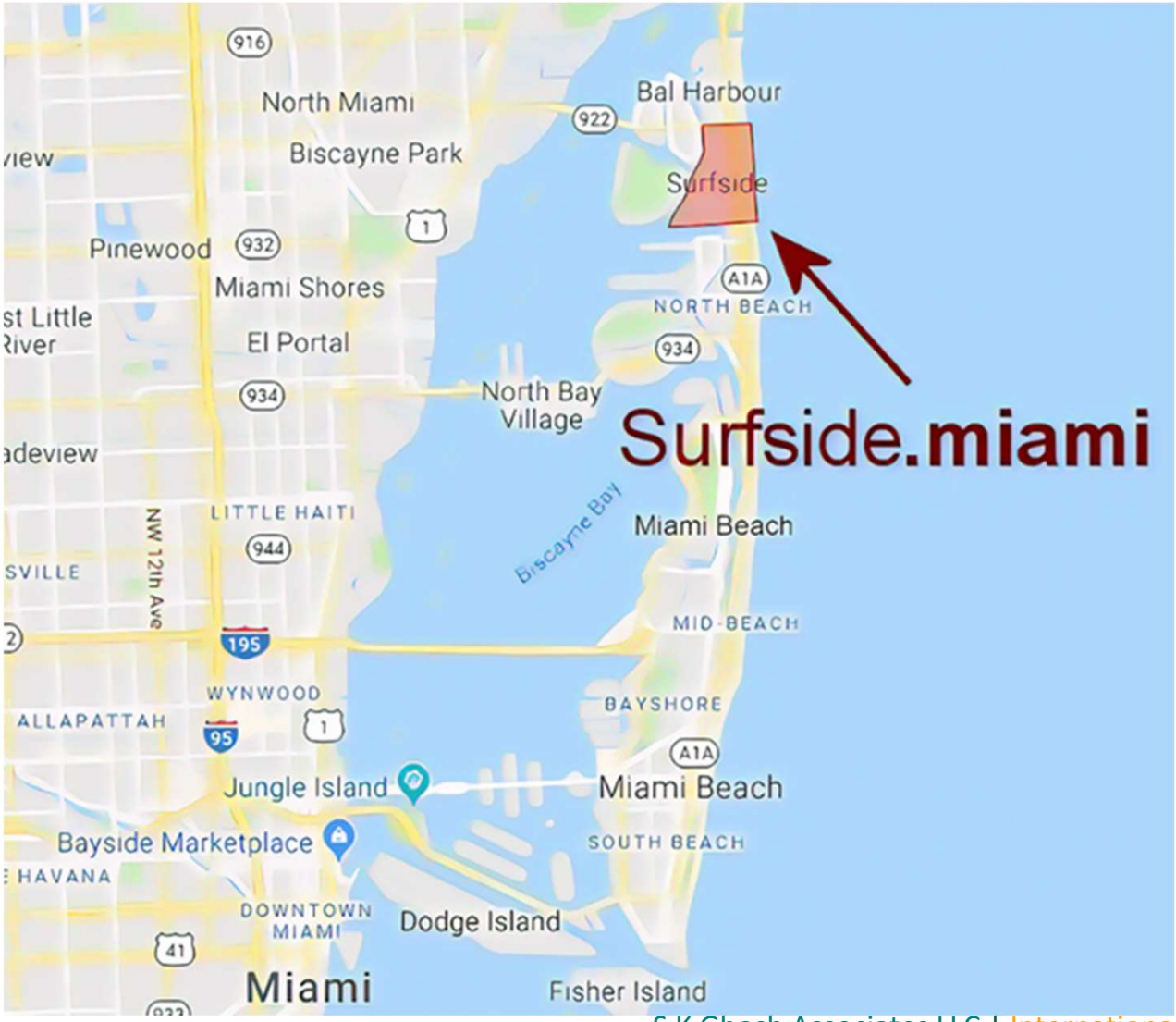
Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete: Part 2 of 4

S. K. Ghosh, S. K. Ghosh Associates LLC

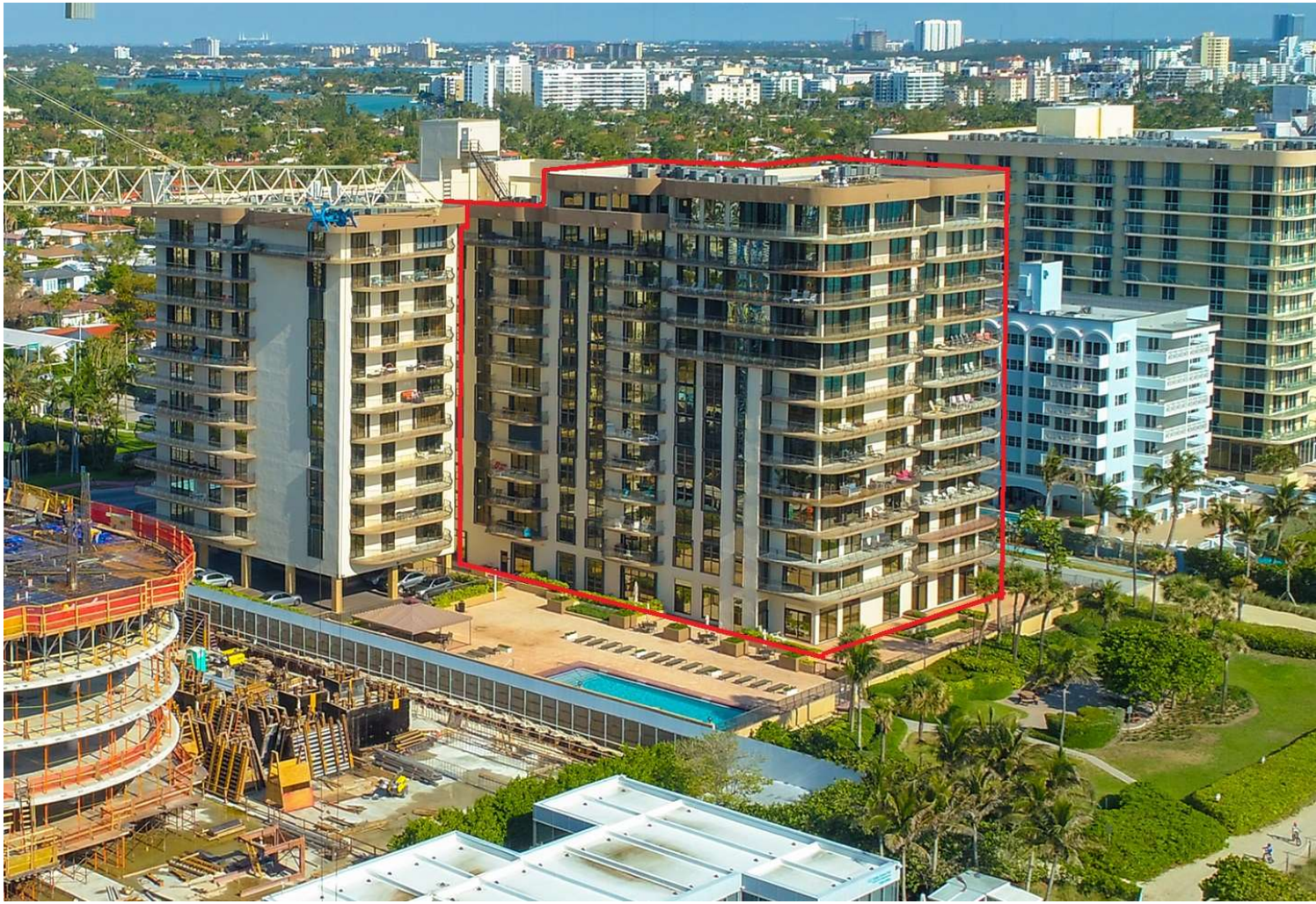
Palatine, IL

The Event

On **Thursday, June 24, 2021**, at approximately 1:25 a.m. EDT, Champlain Towers South, a 12-story beachfront condominium in the Miami suburb of Surfside, Florida, partially collapsed. Ninety-eight people died.


916
North Miami
Bal Harbour
922
Biscayne Park
Surfside
1
Pinewood
932
Miami Shores
A1A
NORTH BEACH
El Portal
934
934
North Bay
Village
Surfside.miami
LITTLE HAITI
Miami Beach
944
NW 12th Ave
Biscayne Bay
MID-BEACH
195
WYNWOOD
BAYSHORE
ALLAPATTAH
95
1
A1A
Jungle Island
Miami Beach
Bayside Marketplace
SOUTH BEACH
HAVANA
DOWNTOWN
MIAMI
Dodge Island
41
Miami
Fisher Island

Champlain Tower South Before Collapse



Before and After Collapse

Critical Improvements in ACI 318 since Building Was Designed

The building was likely designed under the early or mid-1970s Florida Building Code and ACI 318-71 or ACI 318-77. ACI 318 provisions for concrete durability, reinforcement durability, structural integrity, and flat plate – column frame design are critical areas of improvements that engineers, architects, and building officials must be familiar with for safe performance of concrete buildings.

Concrete Durability

Concrete Durability Requirements of ACI 318

Aspects of Concrete Durability:

- Freeze-Thaw Resistance
- Resistance to Sulfate Attack
- Low Permeability
- Corrosion Protection

ACI 318-71 – ACI 318-19

318-71 – Unidentified requirements in Chapter 4, Concrete Quality

318-77 – Requirements under the heading of Special Exposure Requirements in Chapter 4

318-89 – Chapter 4 titled: Durability Requirements

318-08 – Major changes; chapter completely rewritten; Exposure Categories and Classes introduced

318-14 – Reorganization; concrete durability requirements became part of Chapter 19, Concrete (Section 19.3)

318-19 – Only a couple of substantive changes

ACI 318-71 Chapter 4: Concrete Quality

4.2.5 – Concrete that, after curing, will be subject to freezing temperatures while wet shall contain entrained air within limits of Table 4.2.5.

For such concrete made with normal weight aggregate, the water-cement ratio shall not exceed 0.53 by weight.

When the concrete is made with lightweight aggregate, the specified compressive strength f_c' shall be at lest 3750 psi for exposure to fresh water and 4000 psi for exposure to seawater.

ACI 318-71 Chapter 4: Concrete Quality

TABLE 4.2.5 – CONCRETE AIR CONTENT FOR VARIOUS SIZES OF COARSE AGGREGATE

Nominal maximum Size of coarse Aggregate, in.	Total air content, Percent by volume
3/8	6 to 10
1/2	5 to 9
3/4	4 to 8
1	3.5 to 6.5
1-1/2	3 to 6
2	2.5 to 5.5
3	1.5 to 4.5

ACI 318-71 Chapter 4: Concrete Quality

4.2.6 – When made with normal weight aggregate, concrete that is intended to be watertight shall have a maximum water-cement ratio of 0.48 for exposure to fresh water and 0.44 for exposure to sea water.

For concrete made with lightweight aggregate, specified compressive strength f_c' shall be at least 3750 psi for exposure to fresh water and 4000 psi for exposure to seawater.

ACI 318-71 Chapter 4: Concrete Quality

4.2.7 – Concrete that will be exposed to injurious concentrations of sulfate-containing solutions shall conform to Section 4.2.6 and be made with sulfate-resisting cement.

No corrosion protection (introduced in 1989)

ACI 318-77 Chapter 4: Concrete Quality

4.6 – Special exposure requirements

4.6.1~~2.5~~ – Concrete that, after curing, will be exposed~~subject~~ to freezing temperatures while wet shall contain entrained air within limits of Table 4.6.1~~4.2.5~~.

4.6.1.1 - For such concrete made with normal weight aggregate, the water-cement ratio shall not exceed 0.53 by weight.

4.6.1.2 - When the concrete is made with lightweight aggregate, the specified compressive strength f_c' shall be at lest 3000 psi~~3750 psi for exposure to fresh water and 4000 psi for exposure to seawater~~.

ACI 318-77 Chapter 4: Concrete Quality

TABLE 4.6.1~~2.5~~ – CONCRETE AIR CONTENT FOR VARIOUS SIZES OF COARSE AGGREGATE

Same as ACI 318-71 Table 4.2.5

ACI 318-77 Chapter 4: Concrete Quality

4.6.2 – Concrete that is intended to be watertight shall conform to the following:

4.6.2.1~~2.6~~ – ~~When~~For concrete made with normal weight aggregate, ~~concrete that is intended to be watertight shall have a maximum~~ water-cement ratio shall not exceed~~of~~ 0.50~~48~~ by weight for exposure to fresh water and 0.45~~4~~ for exposure to sea water.

4.6.2.2 - For concrete made with lightweight aggregate, specified compressive strength f_c' shall be at least 3750 psi for exposure to fresh water and 4000 psi for exposure to seawater.

ACI 318-77 Chapter 4: Concrete Quality

4.6.3~~2.7~~ – Concrete that will be exposed to injurious concentrations of sulfate-containing solutions shall conform to Section 4.2.6 and be made with sulfate-resisting cement.

No corrosion protection (introduced in 1989)

ACI 318-08 Chapter 4: Durability Requirements

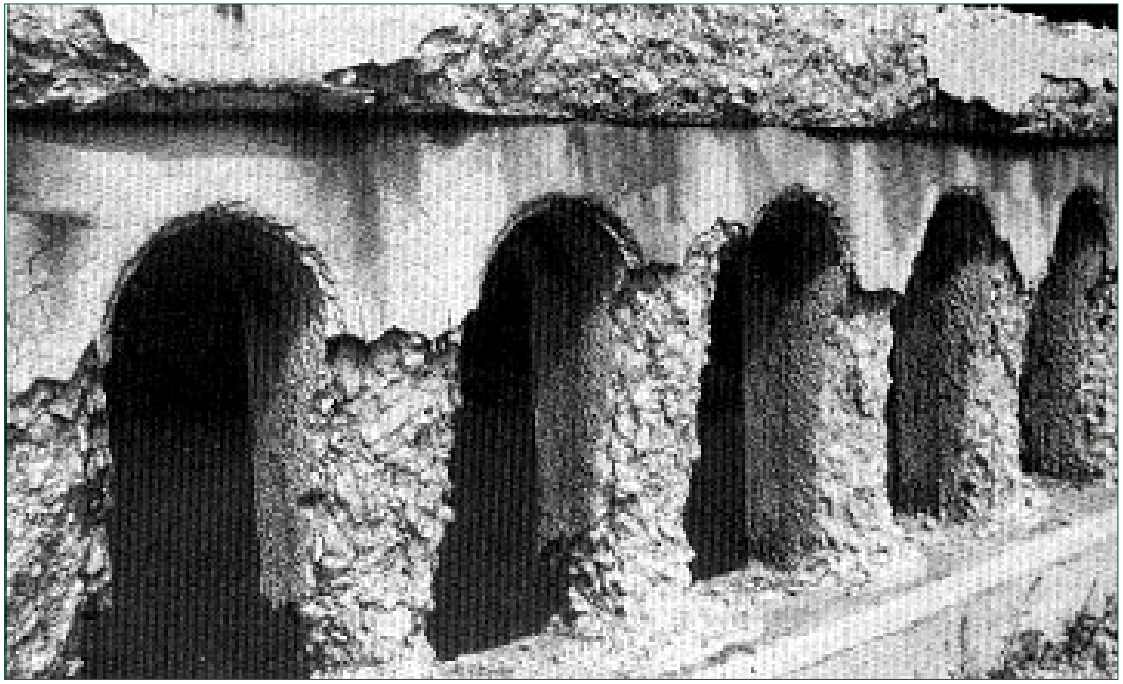
- Format of Chapter 4 extensively revised by introducing exposure categories and classes, with applicable durability requirements given for various classes in a unified format.

ACI 318-08 Chapter 4: Durability Requirements

- Format of Chapter 4 extensively revised by introducing exposure categories and classes, with applicable durability requirements given for various classes in a unified format.

ACI 318-08 Chapter 4: Durability Requirements

Freezing and Thawing



ACI 318-08 Chapter 4: Durability Requirements

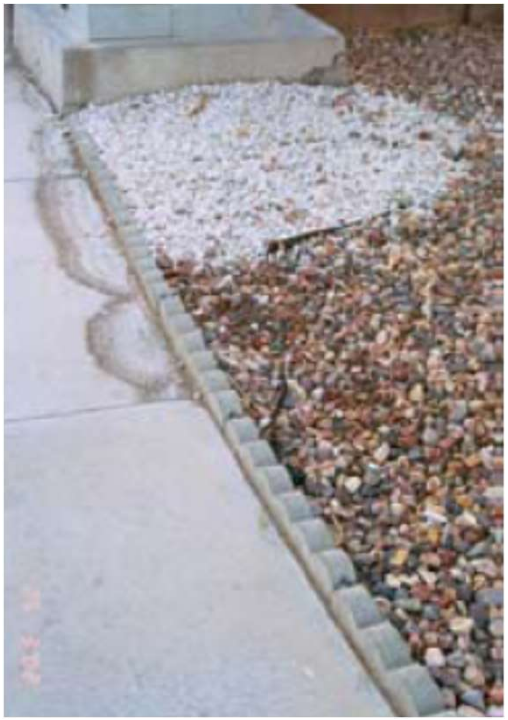
Class	Severity	Condition
F0	Not Applicable	Concrete not exposed to freezing and thawing cycles
F1	Moderate	Concrete exposed to freezing and thawing cycles, which may be occasionally exposed to moisture before freezing. Examples: exterior walls, beams, girders, and slabs not in direct contact with soil
F2	Severe	Concrete exposed to freezing and thawing cycles, which is in continuous contact with moisture before freezing. Examples: water tanks

ACI 318-08 Chapter 4: Durability Requirements

Class	Severity	Condition
F3	Very Severe	Concrete exposed to freezing and thawing cycles, in continuous contact with moisture, where exposure to deicing chemicals is anticipated. Examples: parking structures in northern states

ACI 318-08 Chapter 4: Durability Requirements

Water Soluble Sulfate



ACI 318-08 Chapter 4: Durability Requirements

Class	Severity	Water-Soluble Sulfate in Soil, Percent by Weight	Sulfate in Water ppm	Commentary
S0	Not Applicable	$SO_4 < 0.01$	$SO_4 < 150$	Injurious sulfate attack is not common
S1	Moderate	$0.10 \leq SO_4 < 0.20$	$150 \leq SO_4 <1500$ sea water	More critical value of measured water-soluble sulfate concentration in soil or the concentration of dissolved sulfate in water governs

ACI 318-08 Chapter 4: Durability Requirements

Class	Severity	Water-Soluble Sulfate in Soil, Percent by Weight	Sulfate in Water ppm	Commentary
S2	Severe	$0.20 \leq SO_4 \leq 2.00$	$1500 \leq SO_4 \leq 10{,}000$	Same as above
S3	Very Severe	$SO_4 > 2.00$	$SO_4 > 10{,}000$	Same as above

ACI 318-08 Chapter 4: Durability Requirements

Permeability

Class	Severity	Condition	Commentary
P0	Not Applicable	Concrete not required to have low permeability to water	
P1	Applicable	Concrete required to have low permeability to water	When the permeation of water into concrete might reduce durability or affect the intended function of the structural element

ACI 318-08 Chapter 4: Durability Requirements

Corrosion of Reinforcement

ACI 318-08 Chapter 4: Durability Requirements

Class	Severity	Condition	Commentary
C0	Not Applicable	Concrete that will be dry or protected from moisture in service	No additional protection required against the corrosion of reinforcement
C1	Moderate	Concrete exposed to moisture but not to an external source of chlorides in service	
C2	High	Concrete exposed to moisture and to an external source of chlorides in service	Example sources: deicing chemicals, salt, brackish water, seawater, or spray from these sources

ACI 318-08 4.3 – Requirements for Concrete Mixtures

4.3.1 — Based on the exposure classes assigned from Table 4.2.1, concrete mixtures shall comply with the most restrictive requirements according to Table 4.3.1.

ACI 318-08 Table 4.3.1.a – Exposure Category F

Exposure Class	Max. w/cm**	Min. f'_c psi	Additional Minimum Requirements	
			Air Content	Limits on CM
F0	N/A	2500	N/A	N/A
F1	0.45	4500	Table 4.4.1	N/A
F2	0.45	4500	Table 4.4.1	N/A
F3	0.45	4500	Table 4.4.1	Table 4.4.2

ACI 318-08 Table 4.3.1.b – Exposure Category S

Class	Max. w/cm	Min. f_c' psi	Required Cementitious Materials- Types			Calcium Chloride Admixtures
			C 150	C 595	C 1157	
S0	N/A	2500	--	--	--	--
S1	0.50	4000	II	IP(MS) IS(<70)(MS)	MS	--
S2	0.45	4500	V	IP(HS) IS(<70)(HS)	HS	Not Permitted
S3	0.45	4500	V + Pozzolan or Slag	[IP(HS) or IS(<70)(HS)] + Pozzolan or Slag	HS + Pozzolan or Slag	Not Permitted

ACI 318-08 Table 4.3.1.c – Exposure Category P

Exposure Class	Max. w/cm	Min. f'_c psi	Additional Minimum Requirements
P0	N/A	2500	None
P1	0.50	4000	None

ACI 318-08 Table 4.3.1.d – Exposure Category C

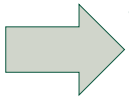
Class	Max. w/cm	Min. f_c' psi	Max. Water-Soluble Chloride Ion (CL^-) Content in Concrete, % by Weight of Cement*		Related Provisions
			Reinforced	Prestressed	
C0	N/A	2500	1.00	0.06	None
C1	N/A	2500	0.30	0.06	None
C2	0.40	5000	0.15	0.06	7.7.6, 18.16#

* Water-soluble chloride ion content that is contributed from the ingredients including water, aggregates, cementitious materials, and admixtures shall be determined on the concrete mixture by ASTM C1218 at age between 28 and 42 days.

Requirements of 7.7.6 shall be satisfied. See 18.16 for unbonded tendons.

ACI 318-14 Chapter 19 Durability of Concrete

Permeability is a material property and not a durability exposure condition. Therefore, Category P is renamed Category W to represent concrete members in contact with water that require low permeability. There are no changes to the requirements.

P  **W**

The whole “Severity” column in former Table 4.2.1 is deleted.

ACI 318-19 19.3 Concrete Durability Requirements: Exposure to Water

Exposure Class W0 is split into W0 and W1, and the old W1 is renamed W2

ACI 318-14 Table 19.3.1.1

In contact with water (W)	W0	Concrete dry in service Concrete in contact with water and low permeability is not required
	W1	Concrete in contact with water and low permeability is required

Renamed W2

New W1

ACI 318-19 19.3 Concrete Durability Requirements: Exposure to Water

Requirements for Exposure Category W are updated in Table 19.3.2.1

ACI 318-19 Table 19.3.2.1

Exposure Class	Maximum w/cm	Minimum f_c', psi	Additional requirements	Limits on cementitious materials
			Air content	
W0	N/A	2500	None	
W1	N/A	2500	26.4.2.2(d)	
~~W1~~ W2	0.50	4000	~~None~~ 26.4.2.2(d)	

ACI 318-14 19.3 Concrete Durability Requirements: Exposure to Water

26.4.2.2(d) For concrete identified as being exposed to water in service, evidence shall be submitted that the concrete mixture complies with (1) and (2).

1) Aggregates are not alkali-silica reactive or measures to mitigate alkali-silica reactivity have been established.
2) Aggregates are not alkali-carbonate reactive.

19.3 Concrete Durability Requirements: Exposure to Sulfate

An Option 2 is added in the requirements for Exposure Class S3 in Table 19.3.2.1

- Maximum w/cm reduced to 0.40 from 0.45
- Minimum f_c' increased to 5000 psi from 4500 psi
- Allows use of Type V cements without pozzolans or slag cement
- Allows use of C595 HS and C1157 HS blended cements without additional pozzolans or slag cement

DURABILITY OF REINFORCEMENT
Concrete Cover

Concrete Protection for Reinforcement – ACI 318-71

7.14.1- The following minimum concrete cover shall be provided for reinforcing bars, prestressing tendons, or ducts. For bar bundles, … .

7.14.1.1 – Cast-in-place concrete (nonprestressed)

7.14.1.2 – Precast concrete (manufactured under plant control conditions)

7.14.1.3 – Prestressed concrete members – Prestressed and nonprestressed reinforcement, ducts, and end fittings

Concrete Protection for Reinforcement – ACI 318-71

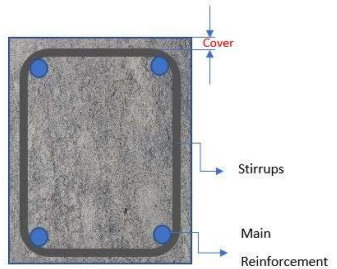
7.14.3 — In corrosive environments or other severe exposure conditions, the amount of concrete protection shall be suitably increased, and the denseness and nonporosity of the protecting concrete shall be considered, or other protection shall be provided.

7.14.4 — Exposed reinforcing bars, inserts, and plates intended for bonding with future extensions shall be protected from corrosion.

Concrete Protection for Reinforcement – ACI 318-95, -99

7.7.5.1 — For prestressed concrete members exposed to corrosive environments or other severe exposure conditions, and which are classified as Class T or C in 18.3.3, minimum cover to the prestressed reinforcement shall be increased 50 percent. This requirement shall be permitted to be waived if the precompressed tensile zone is not in tension under sustained loads.

Concrete Protection for Reinforcement – ACI 318-02



7.7 – Concrete protection for reinforcement

7.7.1 – Cast-in-place concrete (nonprestressed)

The following minimum concrete cover shall be provided for reinforcement, but shall not be less than required by 7.7.5 [Corrosive environments] and 7.7.7 [Fire protection]:

7.7.2~~2~~3 – Precast concrete (manufactured under plant control conditions)

Concrete Protection for Reinforcement – ACI 318-02

The following minimum concrete cover shall be provided for prestressed and nonprestressed reinforcement, ducts, and end fittings, but shall not be less than required by 7.7.5, 7.7.5.1, and 7.7.7:

7.7.~~3~~2 – Cast-in-place concrete (~~P~~prestressed) ~~concrete~~

The following minimum concrete cover shall be provided for prestressed and non prestressed reinforcement, ducts, and end fittings, but shall not be less than required by 7.7.5, 7.7.5.1, and 7.7.7:

Concrete Protection for Reinforcement – ACI 318-08

Specified cover replaces ~~minimum~~ cover.

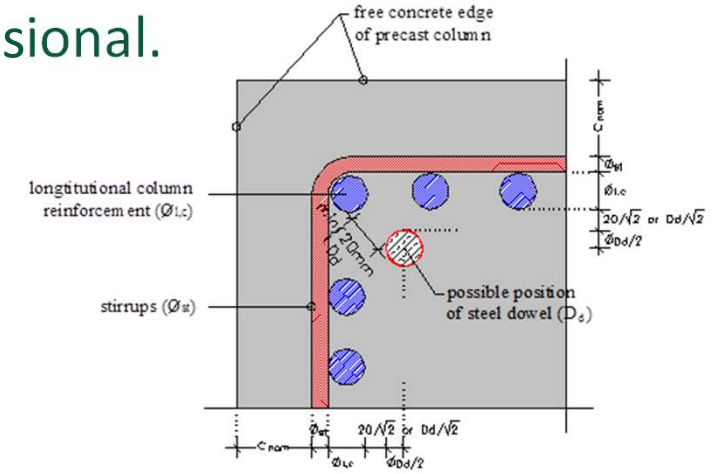
318-11 Chapter 7 – Details of Reinforcement

7.7.5 – Headed shear stud reinforcement

For headed shear stud reinforcement, specified concrete cover for the heads and base rails shall be at least that required for the reinforcement in the member.

318-11 Chapter 7 – Details of Reinforcement

7.7.6 — In this section on corrosive environments and other severe exposure, “amount of concrete protection shall be suitably increased” was changed to: “the concrete cover shall be increased as deemed necessary and specified by the licensed design professional.



318-14 Chapter 20 – Steel Reinforcement Properties, Durability, and Embedments

20.6—Provisions for durability of steel reinforcement

20.6.1 *Specified concrete cover*

20.6.1.1 Unless the general building code requires a greater concrete cover for fire protection, the minimum specified concrete cover shall be in accordance with 20.6.1.2 through 20.6.1.4.

318-14 Durability of Steel Reinforcement

20.6.1.3 *Specified concrete cover requirements*

20.6.1.3.1 Nonprestressed cast-in-place concrete members shall have specified concrete cover for reinforcement at least that given in Table 20.6.1.3.1.

20.6.1.3.2 Cast-in-place prestressed concrete members shall have specified concrete cover for reinforcement, ducts, and end fittings at least that given in Table 20.6.1.3.2.

318-14 Durability of Steel Reinforcement

20.6.1.3 *Specified concrete cover requirements*

20.6.1.3.3 Precast nonprestressed or prestressed concrete members manufactured under plant conditions shall have specified concrete cover for reinforcement, ducts, and end fittings at least that given in Table 20.6.1.3.3.

20.6.1.3.5 For headed shear stud reinforcement, specified concrete cover for the heads and base rails shall be at least that required for the reinforcement in the member.

318-14 Durability of Steel Reinforcement

20.6.1.4 *Specified concrete cover requirements for corrosive environments*

20.6.1.4.1 In corrosive environments or other severe exposure conditions, the specified concrete cover shall be increased as deemed necessary. The applicable requirements for concrete based on exposure categories in 19.3 shall be satisfied, or other protection shall be provided.

318-14 Durability of Steel Reinforcement

20.6.1.4.2 For prestressed concrete members classified as Class T or C in 24.5.2 and exposed to corrosive environments or other severe exposure categories such as those given in 19.3, the specified concrete cover for prestressed reinforcement shall be at least one and one-half times the cover in 20.6.1.3.2 for cast-in-place members and in 20.6.1.3.3 for precast members.

20.6.1.4.3 If the precompressed tension zone is not in tension under sustained loads, 20.6.1.4.2 need not be satisfied.

318-14 Durability of Steel Reinforcement

20.6.2 *Nonprestressed coated reinforcement*

20.6.3 *Corrosion protection for unbonded prestressing Reinforcement*

20.6.4 *Corrosion protection for grouted tendons*

20.6.5 *Corrosion protection for post-tensioning anchorages, couplers, and end fittings*

20.6.6 *Corrosion protection for external post-tensioning*

318-19 Chapter 20 – Steel Reinforcement Properties, Durability, and Embedments

20.5—Provisions for durability of steel reinforcement

New! **20.5.1.3.4** Deep foundation members shall have specified concrete cover for reinforcement at least that given in Table 20.5.1.3.4.

Thank you for participating!

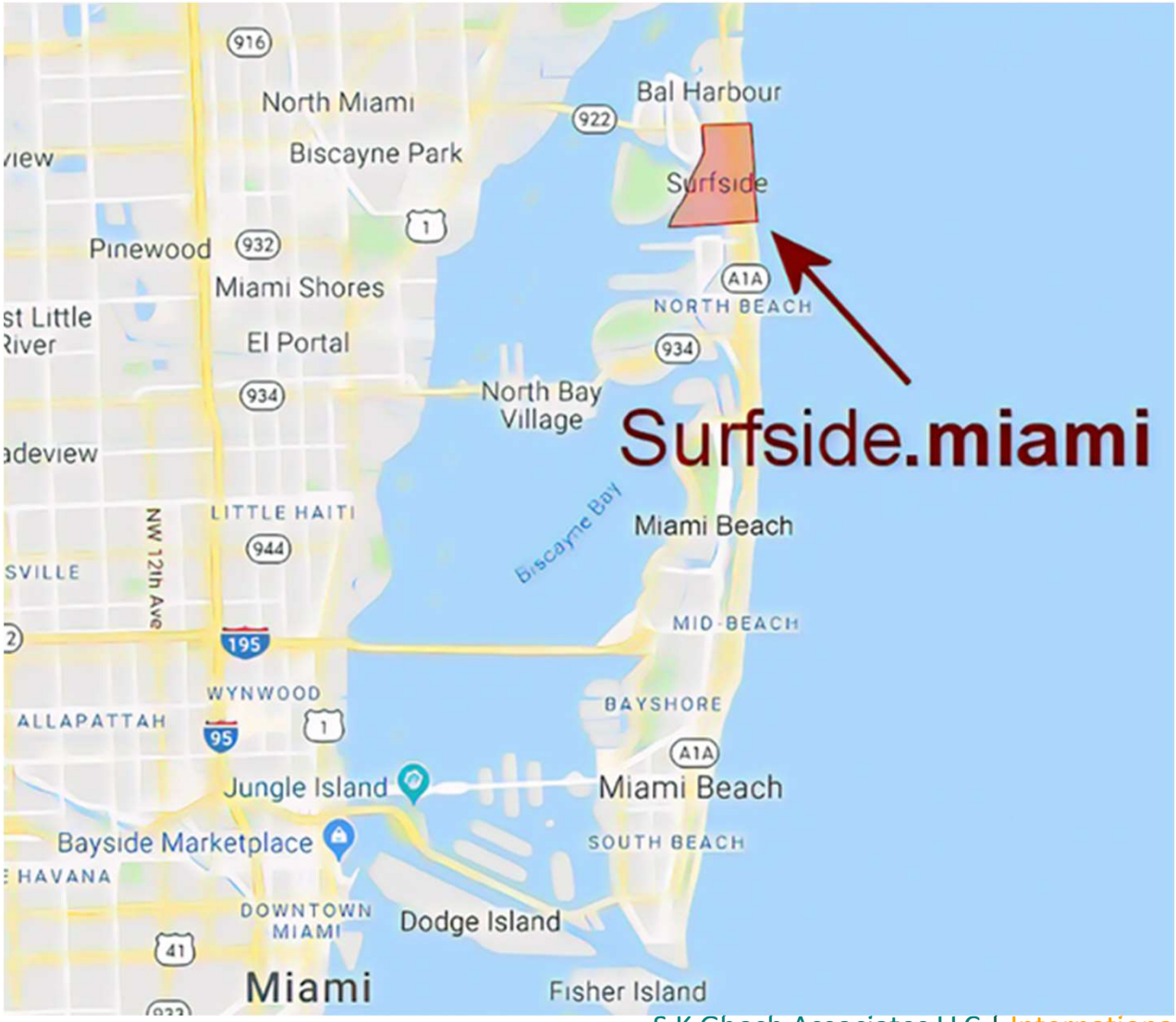
Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete: Part 3 of 4

S. K. Ghosh, S. K. Ghosh Associates LLC

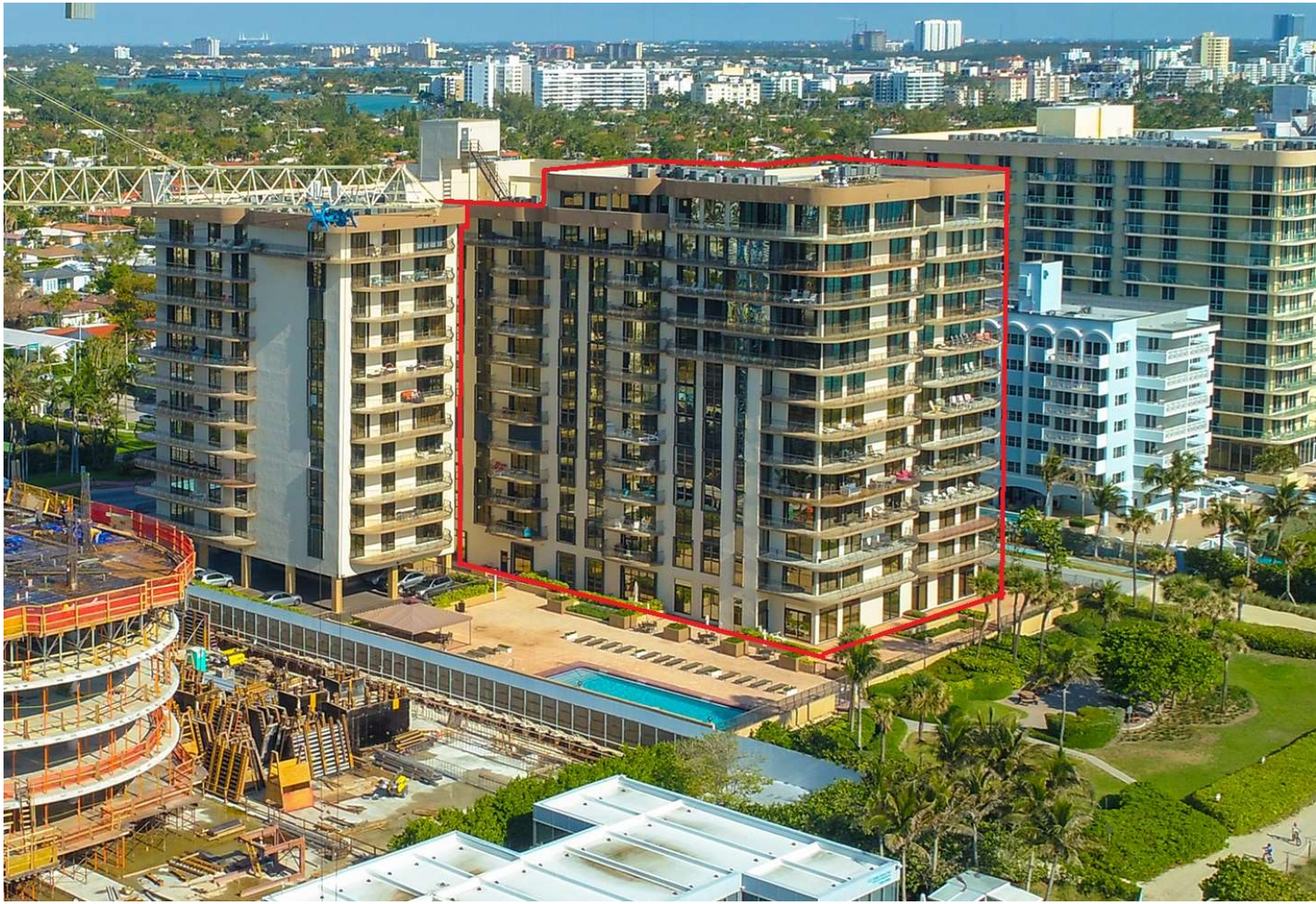
Palatine, IL

The Event

On **Thursday, June 24, 2021**, at approximately 1:25 a.m. EDT, Champlain Towers South, a 12-story beachfront condominium in the Miami suburb of Surfside, Florida, partially collapsed. Ninety-eight people died.


916
North Miami
Bal Harbour
922
Biscayne Park
Surfside
1
Pinewood
932
Miami Shores
A1A
NORTH BEACH
El Portal
934
934
North Bay
Village
Surfside.miami
LITTLE HAITI
Miami Beach
944
Biscayne Bay
NW 12th Ave
MID-BEACH
195
WYNWOOD
BAYSHORE
ALLAPATTAH
95
1
A1A
Jungle Island
Miami Beach
Bayside Marketplace
SOUTH BEACH
HAVANA
DOWNTOWN
MIAMI
Dodge Island
41
Miami
Fisher Island

Champlain Tower South Before Collapse



Before and After Collapse

Critical Improvements in ACI 318 since Building Was Designed

The building was likely designed under the early or mid-1970s Florida Building Code and ACI 318-71 or ACI 318-77. Concrete durability, flat plate punching shear, and structural integrity provisions of ACI 318 are critical areas of improvements that engineers, architects, and building officials must be familiar with for safe performance of concrete buildings.

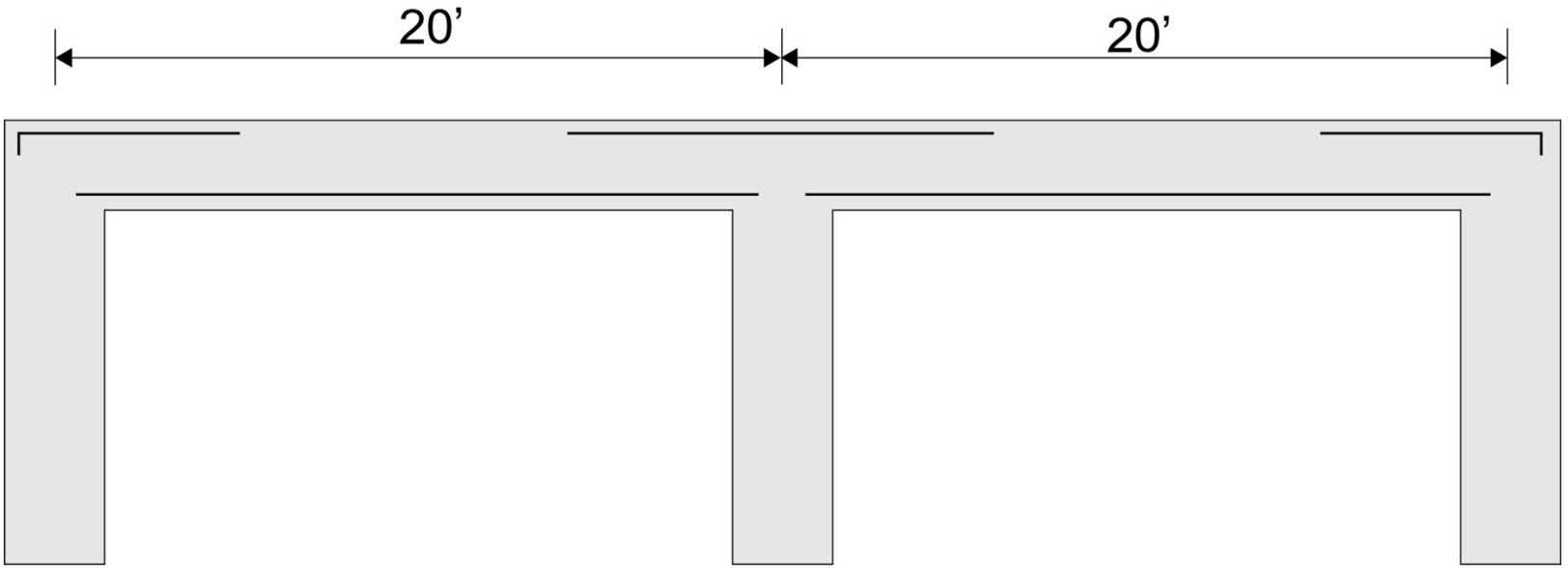
STRUCTURAL INTEGRITY

7.13 – REQUIREMENTS FOR STRUCTURAL INTEGRITY

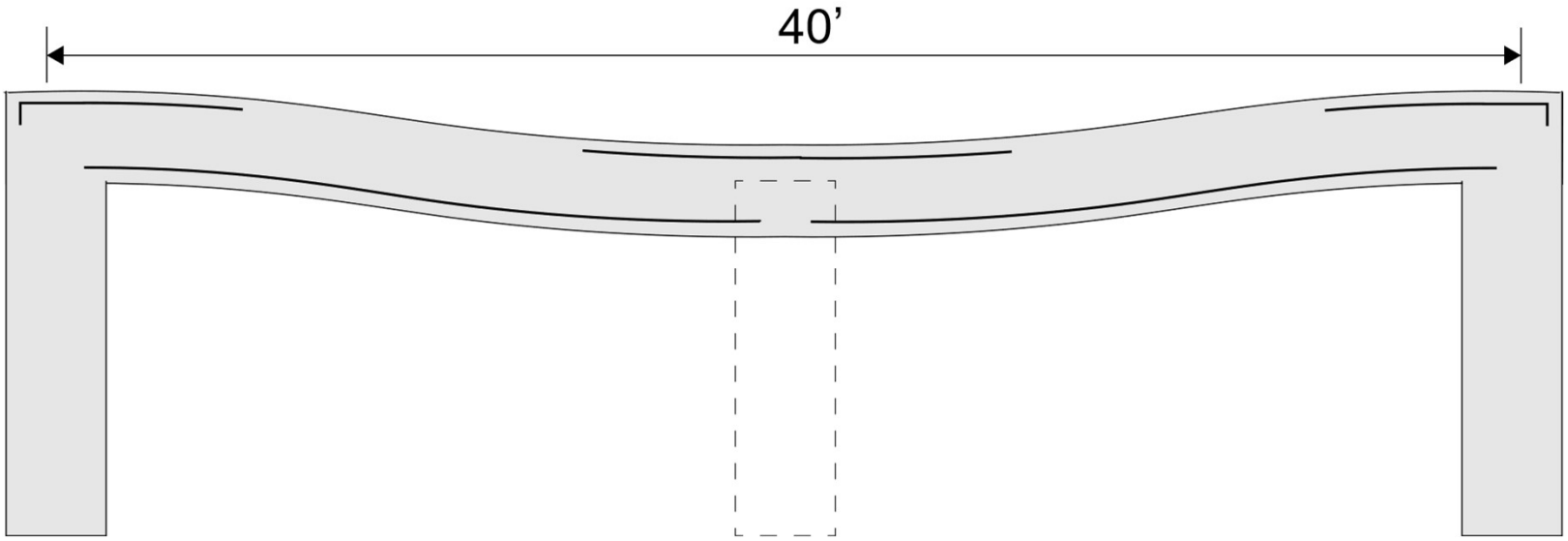
- Introduced in ACI 318-89

- Purpose: To Enhance Overall Integrity of a Concrete Structure through Minor Changes in Detailing of Reinforcement - without Impacting Economy

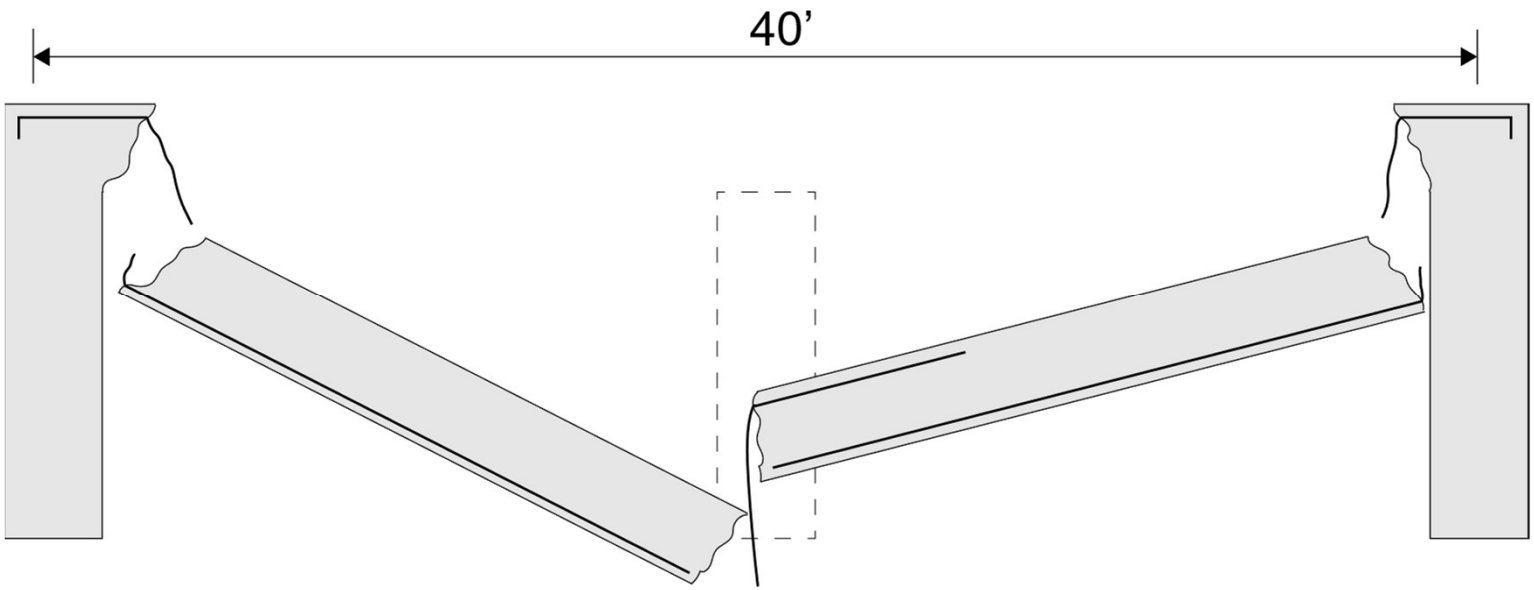
WITHOUT CONTINUOUS BOTTOM REINFORCEMENT



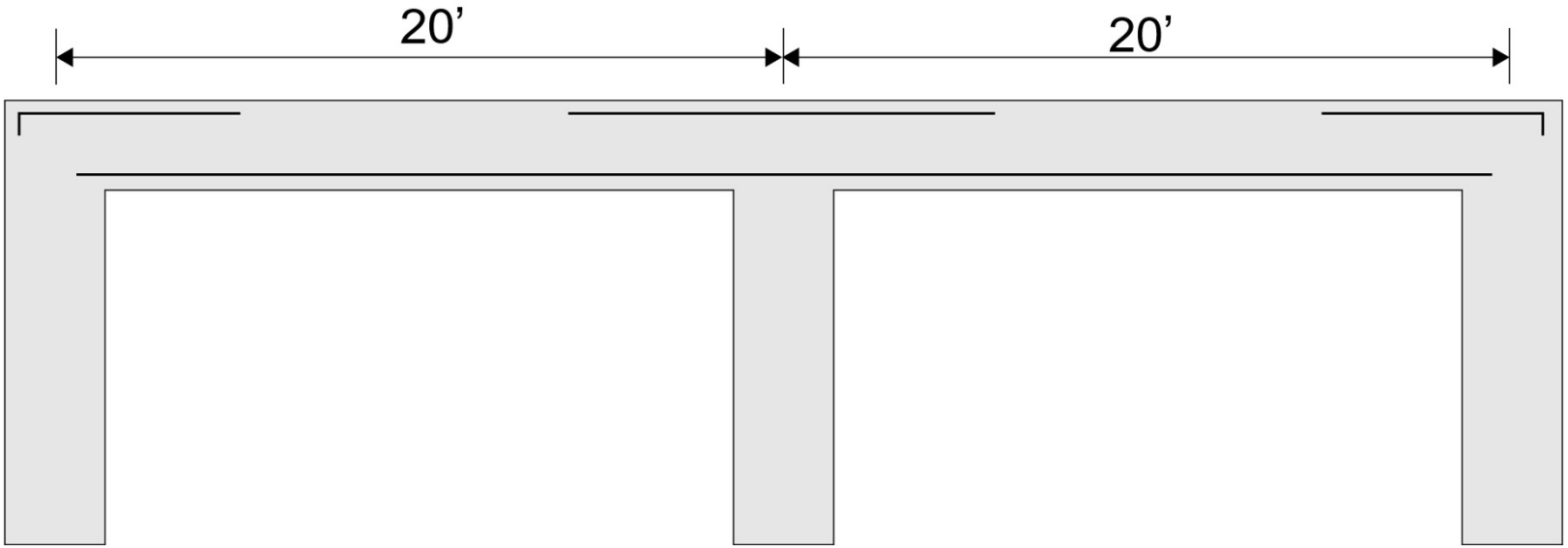
WITHOUT CONTINUOUS BOTTOM REINFORCEMENT



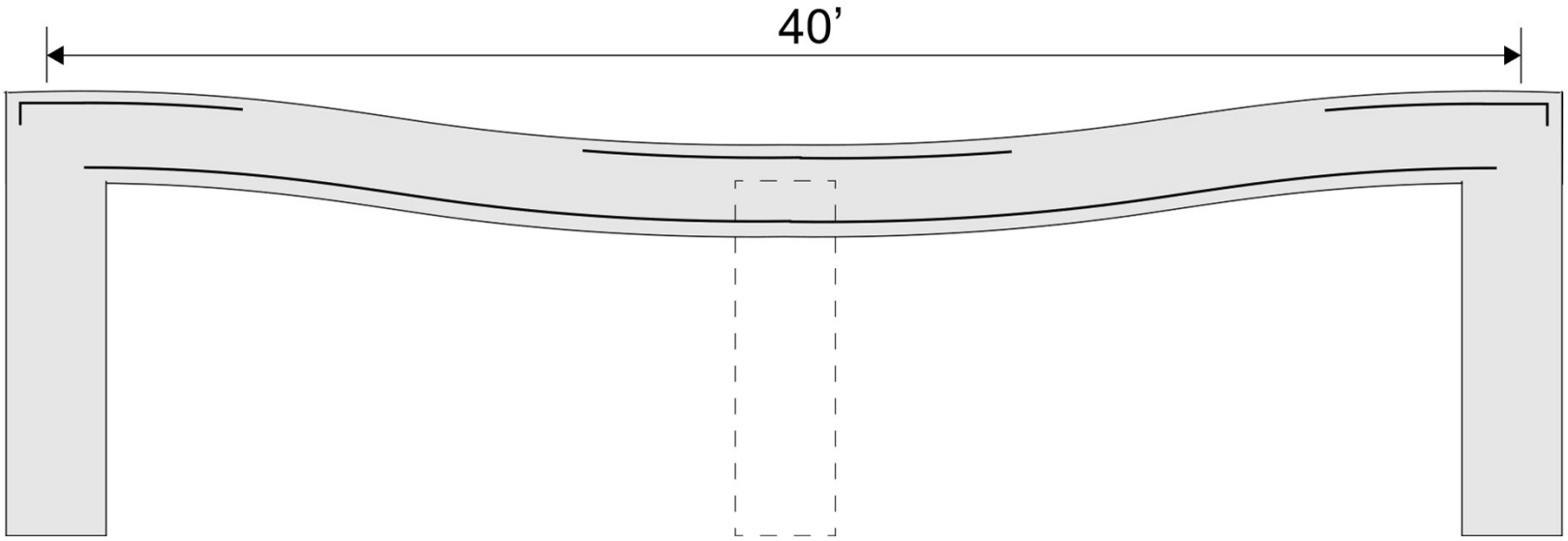
WITHOUT CONTINUOUS BOTTOM REINFORCEMENT



WITH CONTINUOUS BOTTOM REINFORCEMENT



WITH CONTINUOUS BOTTOM REINFORCEMENT



Ronan Point (1968) Explosion on 18th Floor of 22 Floors

Ronan Point

Load-Bearing Precast Panels

Explosion in Lower Story

Local Damage

S K Ghosh Associates LLC | International Code Council

Progressive Collapse vs. Structural Integrity

- Design against progressive collapse requires extensive analysis and design assuming loss of one member at a time
- ACI 318 structural integrity requirements call for minor changes in detailing of reinforcement – no analysis is needed

318-89 – 318-11 7.13 - Requirements for structural integrity

7.13.1 -In the detailing of reinforcement and connections, members of a structure shall be effectively tied together to improve integrity of the overall structure.

318-89 – 318-11 R7.13 – Structural Integrity Requirements

Experience has shown that the overall integrity of a structure can be substantially enhanced by minor changes in detailing of reinforcement. It is the intent of this section of the Code to improve the redundancy and ductility in structures so that in the event of damage to a major supporting element or an abnormal loading event, the resulting damage may be confined to a relatively small area and the structure will have a better chance to maintain overall stability.

318-14 Structural Integrity Requirements after Reorganization

4.10.1.1 Reinforcement and connections shall be detailed to tie the structure together effectively and to improve overall structural integrity.

318-14 Structural Integrity Requirements after Reorganization

4.10.2 *Minimum requirements for structural integrity*

4.10.2.1 Structural members and their connections shall be in accordance with structural integrity requirements in Table 4.10.2.1.

318-14 Structural Integrity Requirements after Reorganization

Table 4.10.2.1—Minimum requirements for structural integrity

Member type	Section
Nonprestressed two-way slabs	8.7.4.2
Prestressed two-way slabs	8.7.5.6
Nonprestressed two-way joist systems	8.8.1.6
Cast-in-place beam	9.7.7
Nonprestressed one-way joist system	9.8.1.6
Precast joints and connections	16.2.1.8

Structural Integrity Requirements of ACI 318

318-89

7.13.1 – General

7.13.2 – Cast-in-place construction

- 7.13.2.1 – Joist construction
- 7.13.22 – Perimeter beams
- 7.13.2.3 – Other than perimeter beams
- 7.13.2.4 – Two-way slab construction; refers to 13.4.8.5

7.13.3 – Precast construction

Structural Integrity Requirements of ACI 318

318-89 (Revised 92)

7.13.4 – Lift-slab construction added

318-95

7.13.2.2 (Perimeter beams) – Addition inserted

7.13.2.4 (Two-way slabs) – Now refers to 13.3.8.5

7.13.3 (Precast construction) – Now refers to 16.5

318-99

No change

Structural Integrity Requirements of ACI 318

318-02

Many changes

Mechanical and welded splices added to Class A tension splices

7.13.2.2 (Perimeter beams) – Split into 7.13.2.2 and 7.13.2.3

Previous 7.13.2.3 (Other than perimeter beams) is now 7.13.2.4

Previous 7.13.2.4 (Two-way slabs) is now 7.13.2.5

318-05

No change

Structural Integrity Requirements of ACI 318

318-08

Many changes

Anchoring at discontinuous supports is now much more specific

Class A tension splice changed to Class B tension splice

7.13.2.2 (Perimeter beams) of 318-89 is now in three sections: 7.13.2.2, 7.13.2.3, 7.13.2.4

Former 7.13.2.4 (Other than perimeter beams is now 7.13.2.5)

Former 7.13.2.5 (Two-way slabs) now split into:

7.13.2.6 – Nonprestressed two-way slabs

7.13.2.7 – Prestressed two-way slabs

Structural Integrity Requirements of ACI 318

318-11

Tension splice changed to tension lap splice

318-14

Reorganization

Structural integrity of two-way joist construction added

318-19

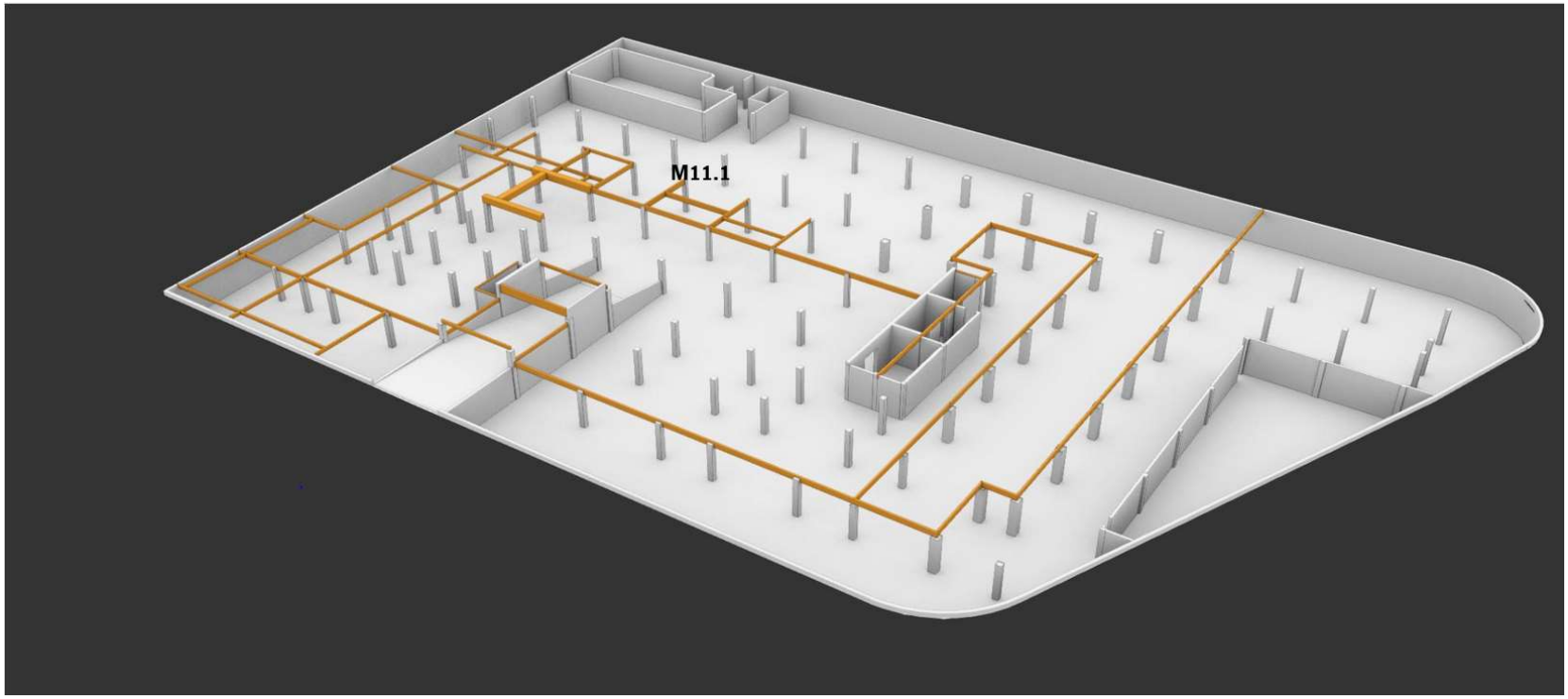
Welded stirrups in accordance with 25.5.7

Class B tension lap splices in accordance with 25.5.2

in Sections 8.7.4.2.1 and 9.7.7.6

CAST-IN-PLACE JOISTS AND BEAMS

Beams Supporting Ground-Level Slab above Basement



Cast-in-Place Construction –Joist Construction

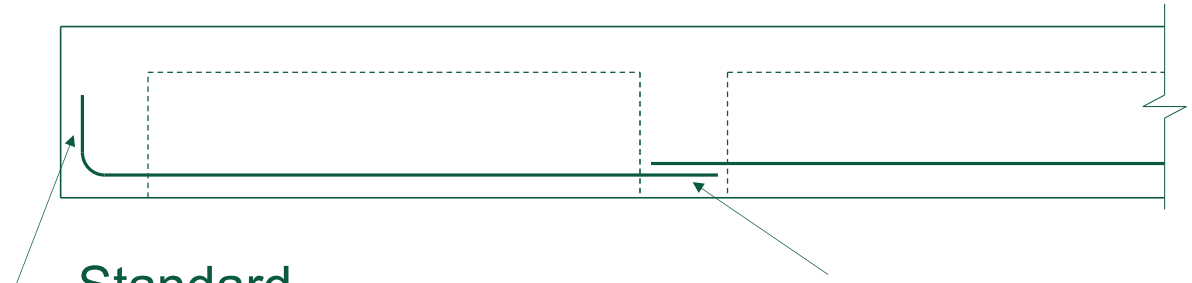
7.13.2 - For cast-in-place construction, the following shall constitute minimum requirements:

7.13.2.1 - In joist construction, at least one bottom bar shall be continuous or shall be spliced over the support with a Class A tension splice and at noncontinuous supports be terminated with a standard hook.

R7.13.2 – Structural Integrity Requirements

With damage to a support, top reinforcement that is continuous over the support, but not confined by stirrups, will tend to tear out of the concrete and will not provide the catenary action needed to bridge the damaged support. By making a portion of the bottom reinforcement continuous, catenary action can be provided.

7.13.2.1 – Joist Construction



Standard Hook

Minimum One Bottom Bar

- Continuous
- Class A Tension Splice (Class B 318-08)
- Mechanical/Welded Splice (318-02)

318-89 7.13.2.2 – Perimeter Beams

Beams at the perimeter of the structure shall have at least one-sixth of the tension reinforcement required for negative moment at the support and one-quarter of the positive moment reinforcement required at midspan made continuous around the perimeter and tied with closed stirrups, or stirrups anchored around the negative moment reinforcement with a hook having a bend of at least 135 deg [ACI 318-95]. Stirrups need not be extended through any joints. When splices are needed, the required continuity shall be provided with top reinforcement spliced at midspan and bottom reinforcement spliced at or near the support with Class A tension splices.

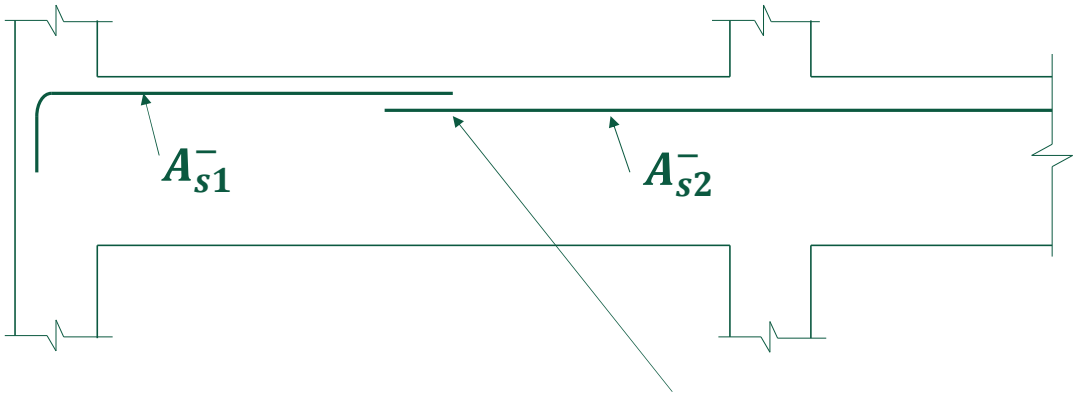
318-89 R7.13.2 – Structural Integrity Requirements

Requiring continuous top and bottom reinforcement in perimeter or spandrel beams provides a continuous tie around the structure. It is not the intent to require a tensile tie of continuous reinforcement of constant size around the entire perimeter of a structure, but simply to require that one half of the top flexural reinforcement required to extend past the point of inflection by 12.12.3 be further extended to lap splice at midspan. Similarly, the bottom reinforcement required to extend into the support by 12.11.1 must be made continuous or spliced with bottom reinforcement from the adjacent span. If the depth of a continuous beam changes at a support, the bottom reinforcement in the deeper member should be terminated with a standard hook and bottom reinforcement in the shallower member should be extended into and fully developed in the deeper member.

ACI 318-89 12.12 – Development of Negative Moment Reinforcement

12.12.3 — At least one-third the total tension reinforcement provided for negative moment at a support shall have an embedment length beyond the point of inflection not less than effective depth of member, $12d_b$, or one-sixteenth the clear span, whichever is greater.

7.13.2.2(a) – Perimeter Beams



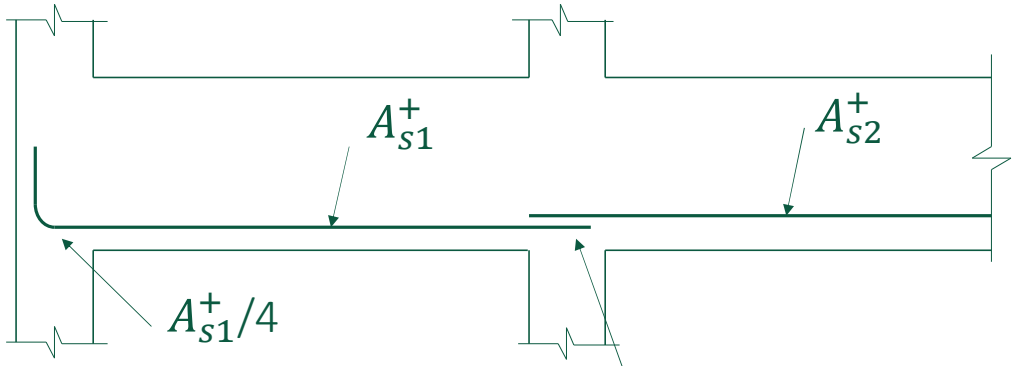
Largest of $A_{s1}^-/6$ or $A_{s2}^-/6$ (Min 2 Bars)

- Continuous
- Class A Tension Splice (Class B 318-08)
- Mechanical/Welded Splice (318-02)

ACI 318-89 12.12 – Development of Positive Moment Reinforcement

ACI 318-89 12.11.1 — At least one-third the positive moment reinforcement in simple members and one-fourth the positive moment reinforcement in continuous members shall extend along the same face of member into the support. In beams, such reinforcement shall extend into the support at least 6 in.

7.13.2.2(b) – Perimeter Beams



$Largest\ of\ A_{s1}^{+}/4\ or\ A_{s2}^{+}/4\ (Min\ 2\ Bars)$

- Continuous
- Class A Tension Splice (Class B 318-08)
- Mechanical/Welded Splice (318-02)

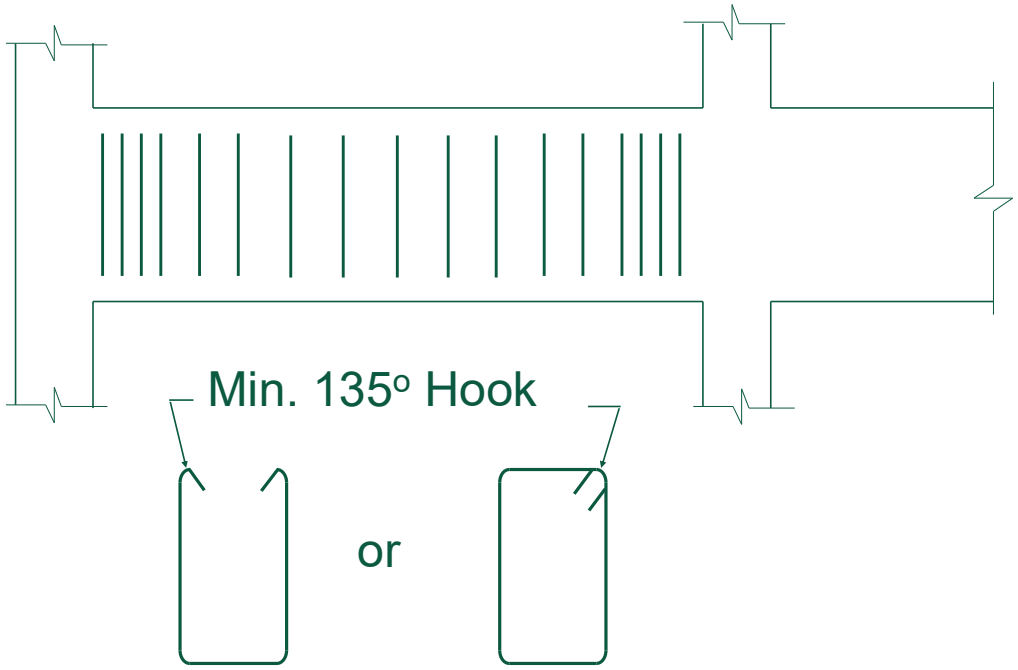
318-02 7.13.2.2 – Perimeter Beams

Beams along the perimeter of the structure
shall have continuous reinforcement consisting of:
(a) at least one-sixth of the tension reinforcement required for negative moment at the support, but not less than two bars; and
(b) at least one-quarter of the tension reinforcement required for positive moment at midspan, but not less than two bars.

318-02 7.13.2.3 – Perimeter Beams

7.13.2.3 — Where splices are needed to provide the required continuity, the top reinforcement shall be spliced at or near midspan and bottom reinforcement shall be spliced at or near the support. Splices shall be Class A tension splices or mechanical or welded splices satisfying 12.14.3. The continuous reinforcement required in 7.13.2.2(a) and 7.13.2.2(b) shall be enclosed by the corners of U-stirrups having not less than 135-deg hooks around the continuous top bars, or by one-piece closed stirrups with not less than 135- deg hooks around one of the continuous top bars. Stirrups need not be extended through any joints.

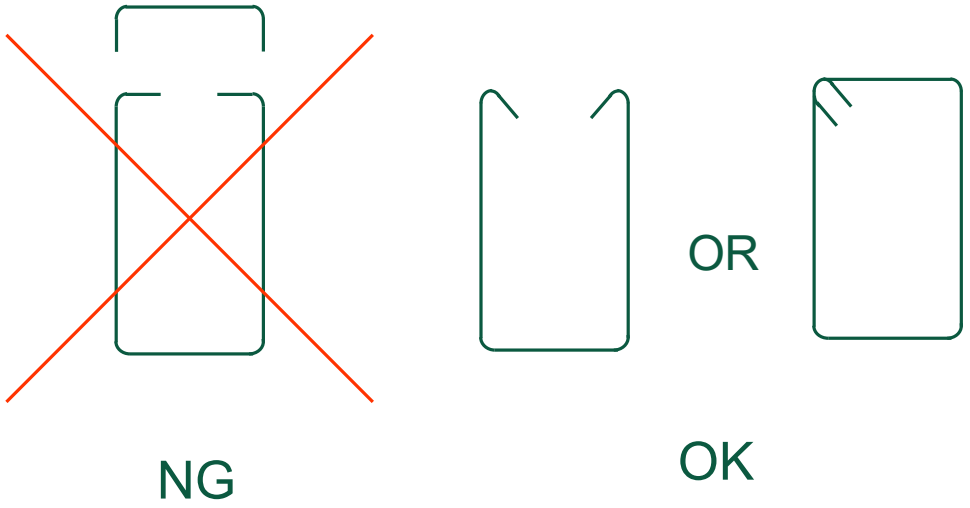
318-02 7.13.2.3 – Perimeter Beams



318-02 R7.13.2.3 – Perimeter Beams

Section 7.13.2 was revised in 2002 to require U-stirrups with not less than 135-deg hooks around the continuous bars, or one-piece close stirrups, because a crosstie forming the top of a two-piece closed stirrup is ineffective in preventing the top continuous bars from tearing out of the top of the beam.

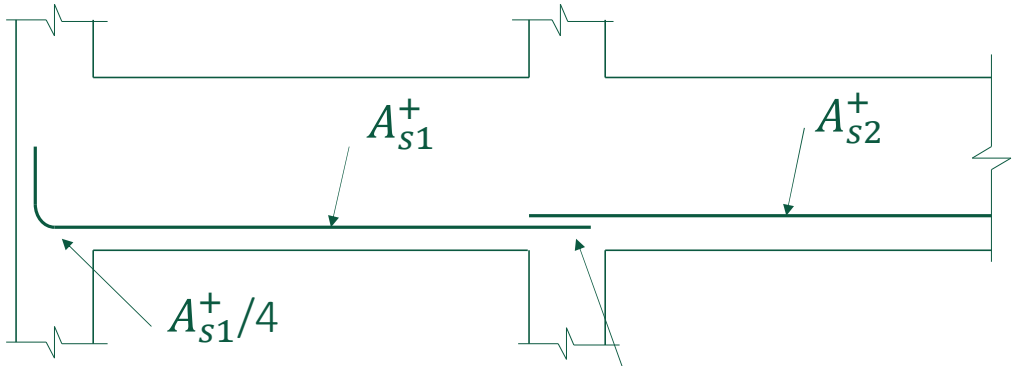
R7.13.2.3 (from 318-02) – Perimeter Beams



318-89 7.13.2.3 (318-02 7.13.2.4) – Other than Perimeter Beams

In other than perimeter beams, when closed stirrups are not provided, at least one-quarter of the positive moment reinforcement required at midspan shall be continuous or shall be spliced over them support with a Class A (Class B 318-08) tension splice and at noncontinuous supports be terminated with a standard hook.

318-89 7.13.2.3 (318-02 7.13.2.4) – Other than Perimeter Beams

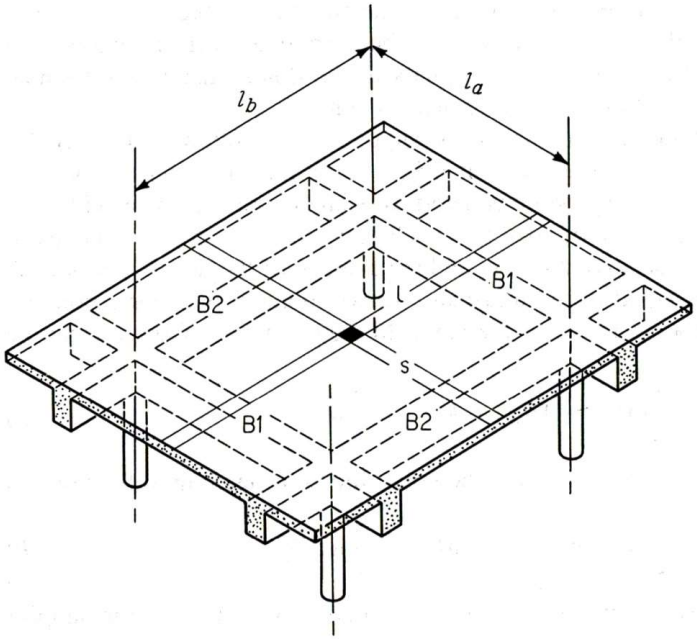


Largest of $A_{s1}^{+}/4$ or $A_{s2}^{+}/4$ (Min 2 Bars)

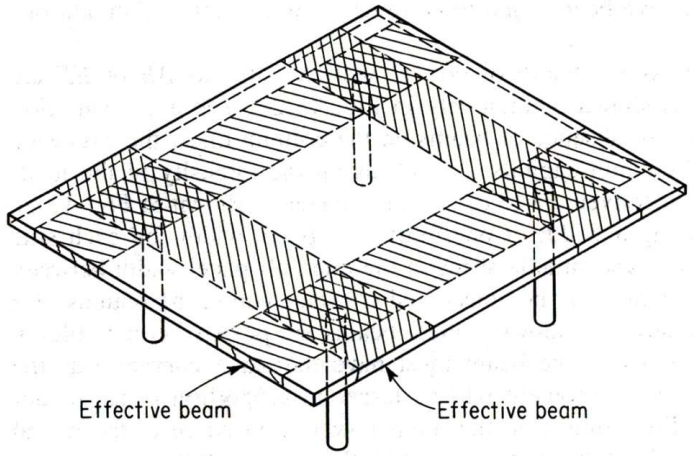
- Continuous
- Class A Tension Splice (Class B 318-08)
- Mechanical/Welded Splice (318-02)

NONPRESTRESSED TWO-WAY SLABS

Column-Supported Two-Way Slabs



Two-Way Slab with Beams



Two-Way Slab without Beams

Source: Nilson, A., Darwin, D., and Dolan, C., *Design of Concrete Structures*, McGraw-Hill, 2009

Punching Shear Failure of Parking Structure Slab

(PHOTO BY SAUL MARTINEZ FOR THE WASHINGTON POST)

The standing columns here suggest the columns “punched through” the deck.

318-89 7.13.2.4 – Two-Way Slab Integrity Reinforcement

For two-way slab construction, see 13.4.8.5.

13.4.8.5 — At least two of the column strip bottom bars or wires in each direction shall be continuous or spliced with Class A splices or anchored within support. These bars shall pass through the column and shall be placed within the column core.

318-95, -99 7.13.2.5 – Two-Way Slab Integrity Reinforcement

7.13.2.5 — For two-way slab construction, see 13.3.8.5.

13.3.8.5 - All bottom bars or wires within the column strip, in each direction, shall be continuous or spliced with Class A splices (or with mechanical or welded splices satisfying 12.14.3 – 318-02, -05) located as shown in Fig. 13.3.8. At least two of the column strip bottom bars or wires in each direction shall pass within the column core and shall be anchored at exterior supports.

318-08 7.13.2.6 – Two-Way Slab Integrity Reinforcement

7.13.2.6 — For nonprestressed two-way slab construction, see 13.3.8.5.

13.3.8.5 — All bottom bars or wires within the column strip, in each direction, shall be continuous or spliced with Class B tension (lap – 318 11)splices or with mechanical or welded splices satisfying 12.14.3. Splices shall be located as shown in Fig. 13.3.8. At least two of the column strip bottom bars or wires in each direction shall pass within the region bounded by the longitudinal reinforcement of the column and shall be anchored at exterior supports.

318-14 8.7.4.2 – Two-Way Slab Integrity Reinforcement

8.7.4.2 *Structural integrity*

8.7.4.2.1 All bottom deformed bars or deformed wires within the column strip, in each direction, shall be continuous or spliced with full mechanical, full welded, or Class B tension splices. Splices shall be located in accordance with Fig. 8.7.4.1.3a.

8.7.4.2.2 At least two of the column strip bottom bars or wires in each direction shall pass within the region bounded by the longitudinal reinforcement of the column and shall be anchored at exterior supports.

318-19 8.7.4.2 – Two-Way Slab Integrity Reinforcement

8.7.4.2 *Structural integrity*

8.7.4.2.1 All bottom deformed bars or deformed wires within the column strip, in each direction, shall be continuous or spliced using mechanical or welded splices in accordance with 25.5.7 or Class B tension lap splices in accordance with 25.5.2. Splices shall be located in accordance with Fig. 8.7.4.1.3.

8.7.4.2.2 [No change]

318-89 (Revised 92) 7.13.4 – Lift-Slab Construction

For lift-slab construction, see 13.4.8.6 and 18.12.6.

Unchanged in 318-95, 318-99, 318-02, 318-05, 318-08, 318-11.

Reference should be made to 8.9.1 in 318-14 and 318-19.

Not discussed

318-14 8.8.1.6 – Nonprestressed Two-Way Joist Construction

8.8.1.6 For structural integrity, at least one bottom bar in each joist shall be continuous and shall be anchored to develop f_y at the face of supports.

POST-TENSIONED TWO-WAY SLABS

ACI 318-08 REQUIREMENTS FOR STRUCTURAL INTEGRITY

7.13.2.7 – For prestressed two-way slab construction, see 18.12.6 and 18.12.7.

18.12.6 — Except as permitted in 18.12.7, in slabs with unbonded tendons, a minimum of two 1/2 in. diameter or larger, seven-wire post-tensioned strands shall be provided in each direction at columns, either passing through or anchored within the region bounded by the longitudinal reinforcement of the column. Outside column and shear cap faces, these two structural integrity tendons shall pass under any orthogonal tendons in adjacent spans. Where the two structural integrity tendons are anchored within the region bounded by the longitudinal reinforcement of the column, the anchorage shall be located beyond the column centroid and away from the anchored span.

ACI 318-08 REQUIREMENTS FOR STRUCTURAL INTEGRITY

18.12.7 — Prestressed slabs not satisfying 18.12.6 shall be permitted provided they contain bottom reinforcement in each direction passing within the region bounded by the longitudinal reinforcement of the column and anchored at exterior supports as required by 13.3.8.5. The area of bottom Reinforcement in each direction shall be not less than 1.5 Times that required by Eq. (10-3) and not less than $300b_w d/f_y$, where b_w is the width of the column face through which the reinforcement passes. Minimum extension of these bars beyond the column or shear cap face shall be equal to or greater than the bar development length required by 12.2.1.

ACI 318-14 REQUIREMENTS FOR STRUCTURAL INTEGRITY

8.7.5.6 *Structural integrity*

8.7.5.6.1 Except as permitted in 8.7.5.6.3, at least two tendons with 1/2 in. diameter or larger strand shall be placed in each direction at columns in accordance with (a) or (b):

(a) Tendons shall pass through the region bounded by the longitudinal reinforcement of the column.

ACI 318-14 REQUIREMENTS FOR STRUCTURAL INTEGRITY

8.7.5.6.1

(b) Tendons shall be anchored within the region bounded by the longitudinal reinforcement of the column, and the anchorage shall be located beyond the column centroid and away from the anchored span.

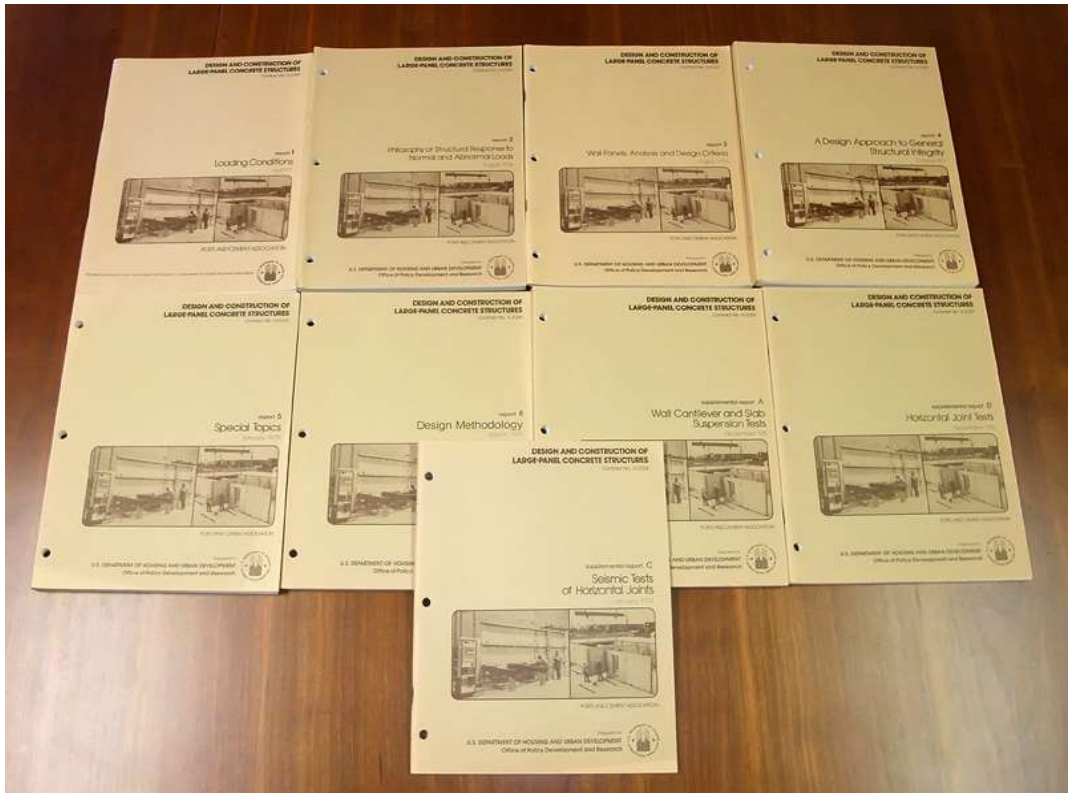
8.7.5.6.2 Outside of the column and shear cap faces, the two structural integrity tendons required by 8.7.5.6.1 shall pass under any orthogonal tendons in adjacent spans.

PRECAST CONCRETE CONSTRUCTION

7.13.3 – Precast Concrete

- Detailed Requirements for Structural Integrity for Precast Concrete Were Introduced in Section 16.5 of ACI 318-95. This Was a Part of the Expansion and Re-write of Chapter 16 in 318-95.

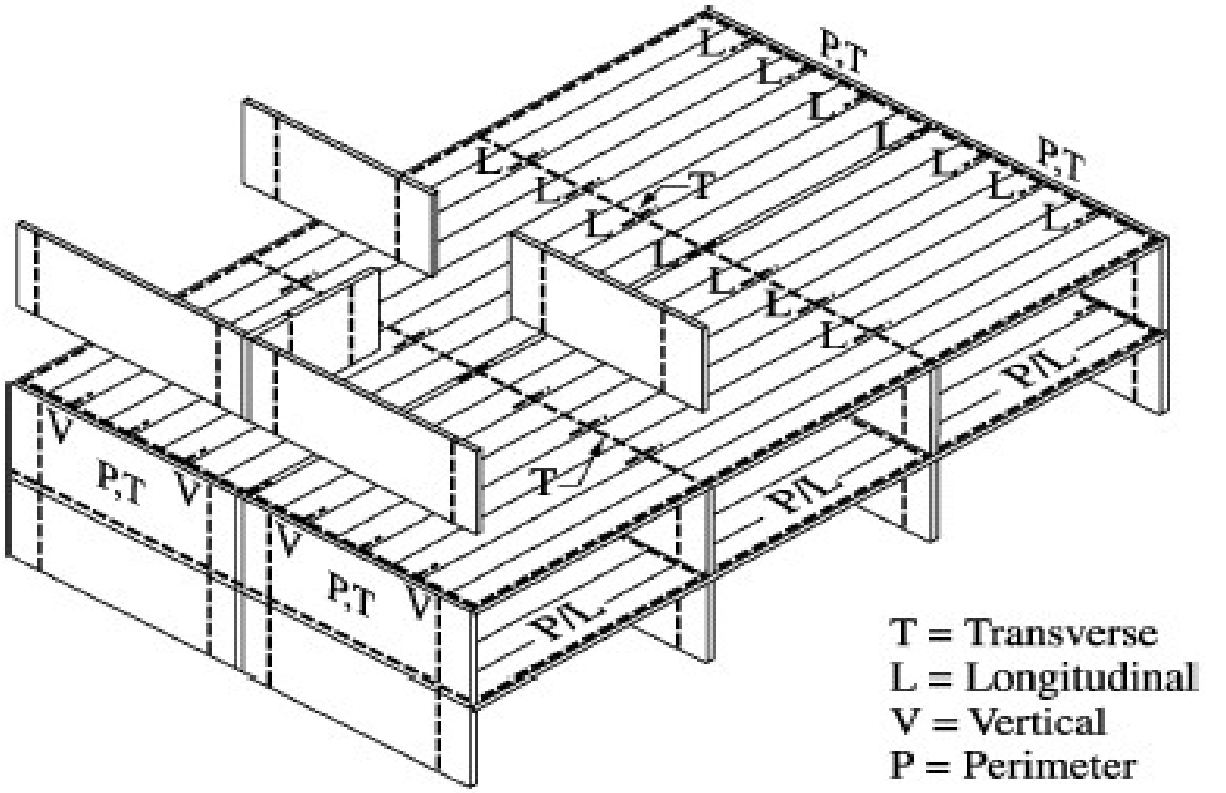
HUD-Sponsored PCA Research, Reports



16.5 – Structural Integrity for Precast Structures

1. Members Must be Connected to the Lateral Load Resisting System. Tension Ties Shall be Provided in the Transverse, Longitudinal, and Vertical Directions and Around the Perimeter of the Structure.
2. The Lateral Load Resisting System Must be Continuous to the Foundation.

16.5 – Structural Integrity



Thank you for participating!

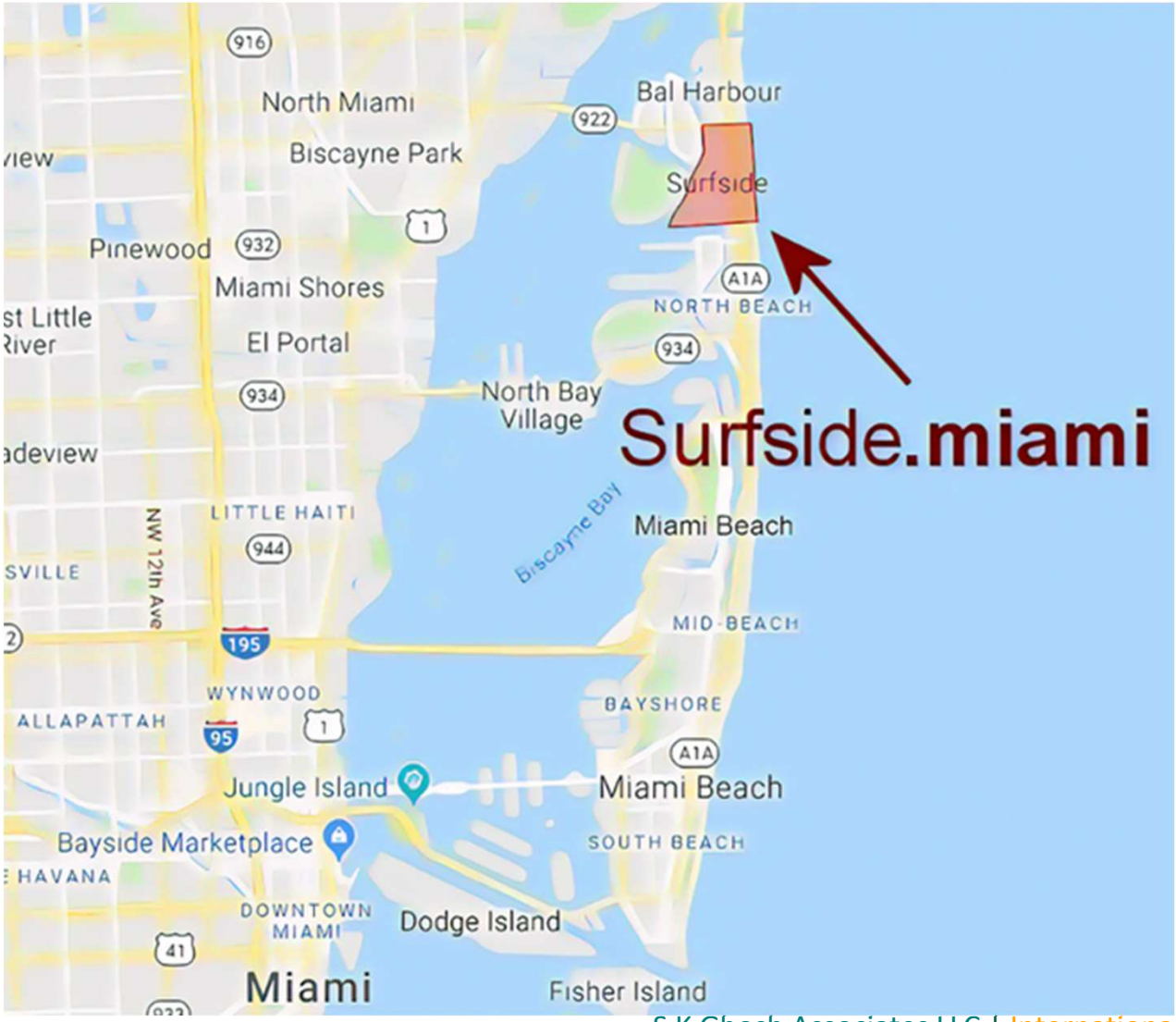
Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete: Part 4 of 4

S. K. Ghosh, S. K. Ghosh Associates LLC

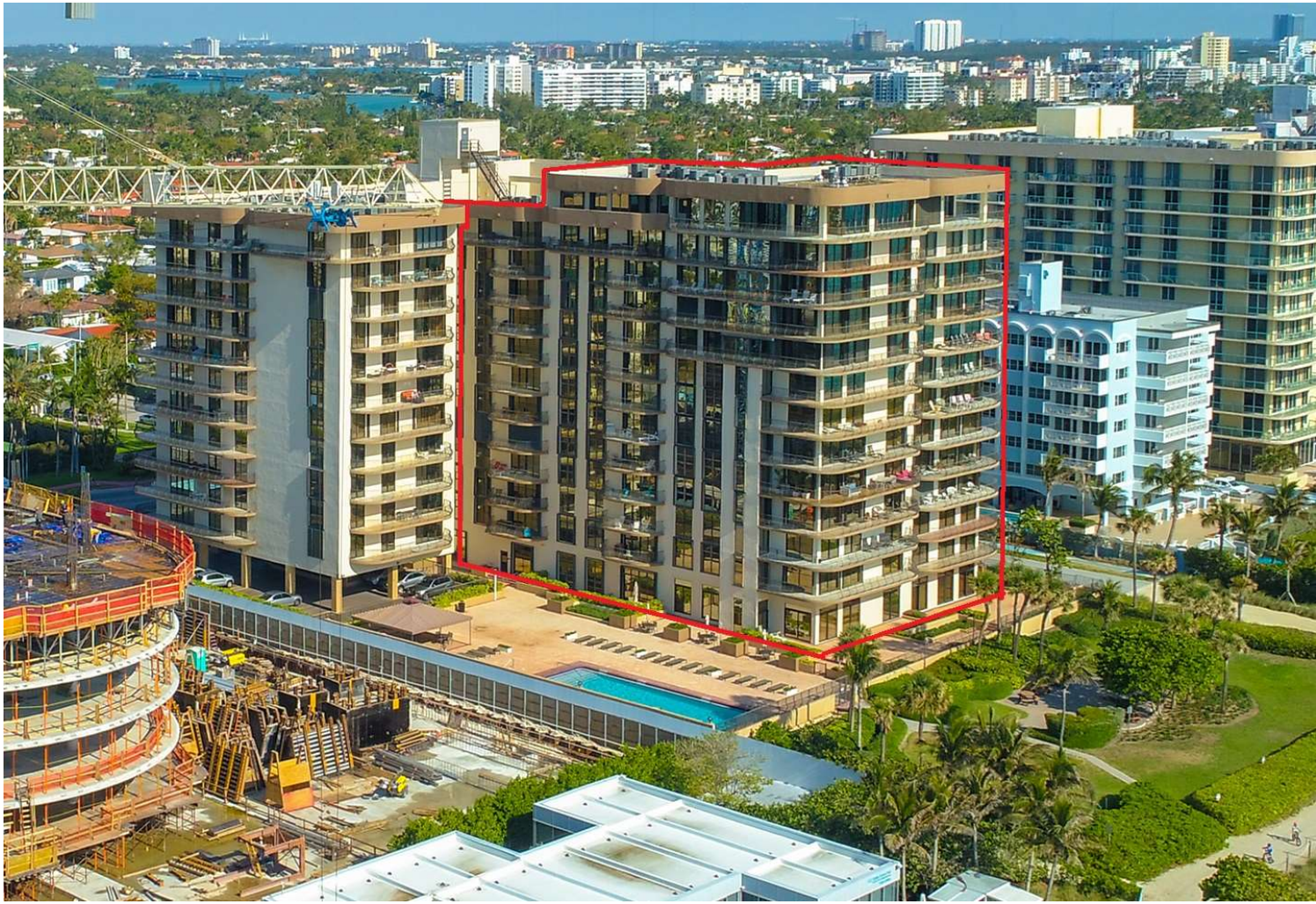
Palatine, IL

The Event

On **Thursday, June 24, 2021**, at approximately 1:25 a.m. EDT, Champlain Towers South, a 12-story beachfront condominium in the Miami suburb of Surfside, Florida, partially collapsed. Ninety-eight people died.


916
North Miami
Bal Harbour
922
Biscayne Park
Surfside
1
Pinewood
932
Miami Shores
A1A
NORTH BEACH
El Portal
934
934
North Bay
Village
Surfside.miami
LITTLE HAITI
Miami Beach
944
Biscayne Bay
NW 12th Ave
MID-BEACH
195
WYNWOOD
BAYSHORE
ALLAPATTAH
95
1
A1A
Jungle Island
Miami Beach
Bayside Marketplace
SOUTH BEACH
HAVANA
DOWNTOWN
MIAMI
Dodge Island
41
Miami
Fisher Island

Champlain Tower South Before Collapse



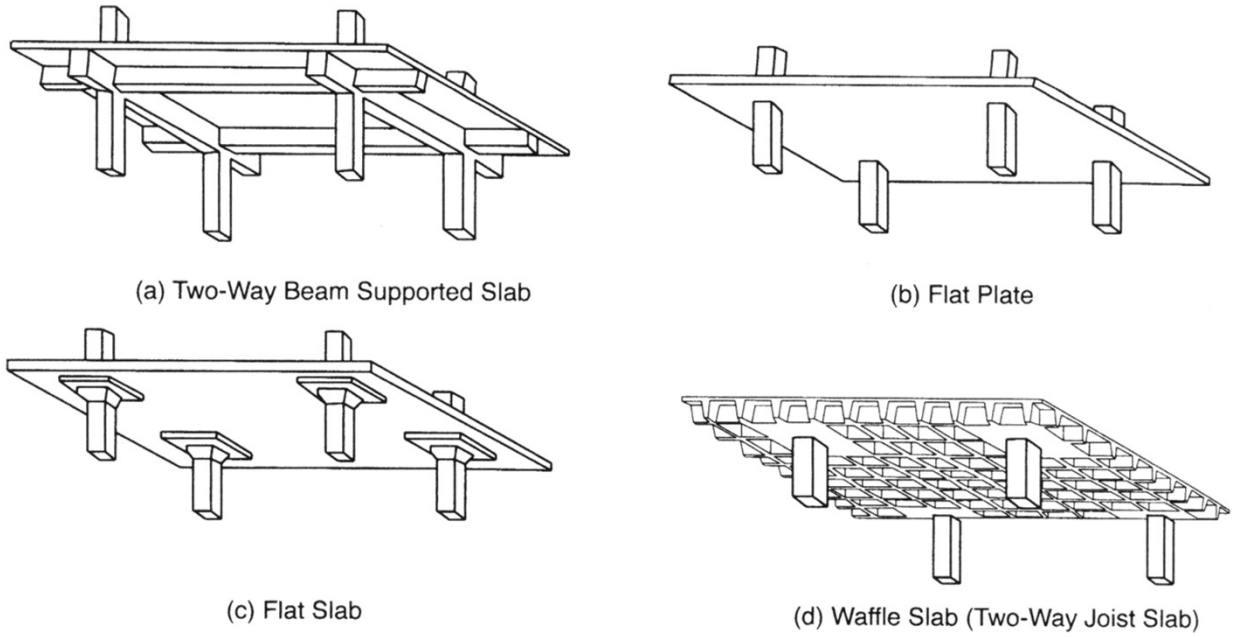
Before and After Collapse

Critical Improvements in ACI 318 since Building Was Designed

The building was likely designed under the early or mid-1970s Florida Building Code and ACI 318-71 or ACI 318-77. Concrete durability, flat plate punching shear, and structural integrity provisions of ACI 318 are critical areas of improvements that engineers, architects, and building officials must be familiar with for safe performance of concrete buildings.

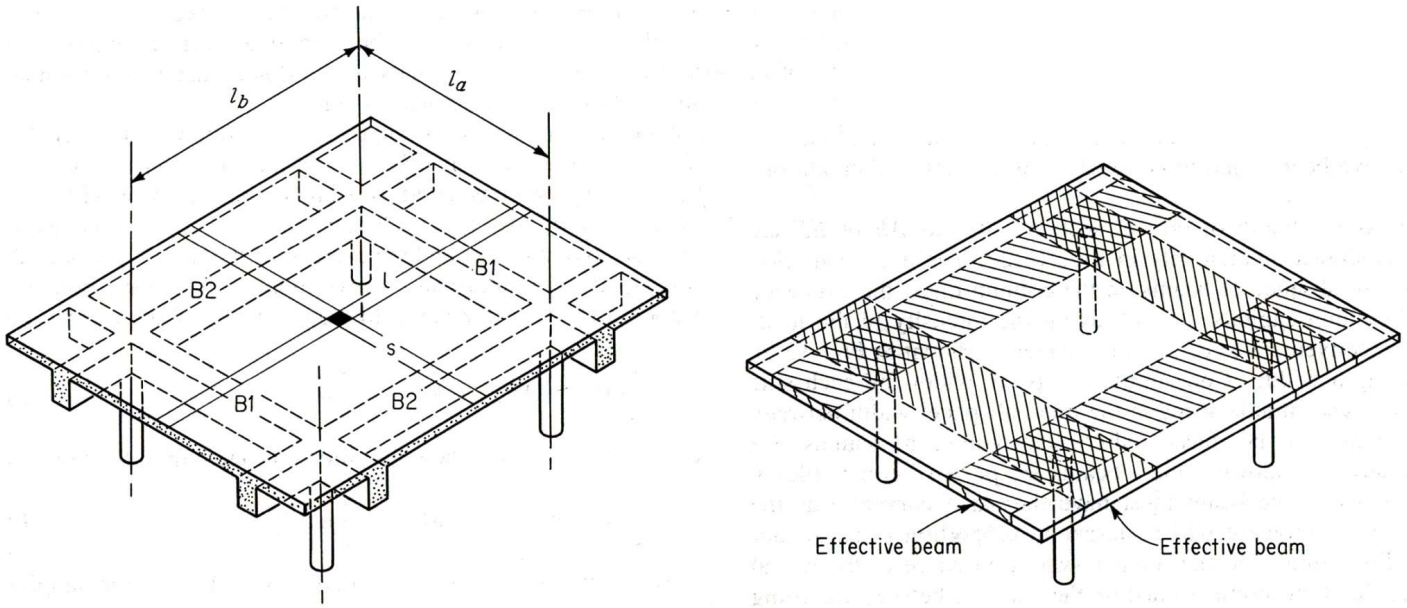
FLAT PLATE – COLUMN FRAMES

Two-Way Concrete Slab Systems



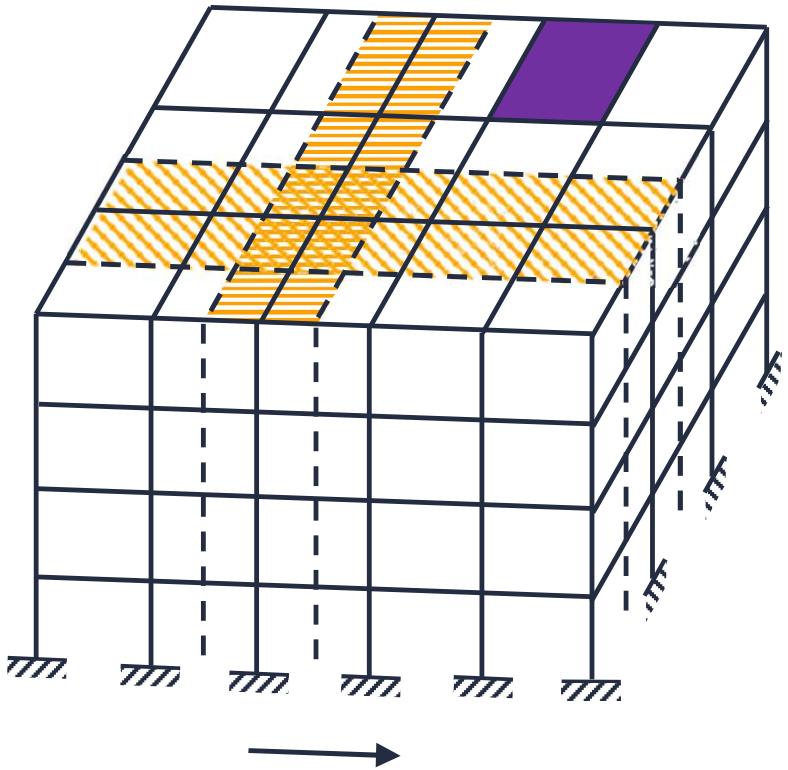
Types of two-way slab systems
(Source: Portland Cement Association, *Notes on ACI 318-08 Building Code Requirements for Structural Concrete*, Skokie, IL, 2008)

Column-Supported Two-Way Slabs

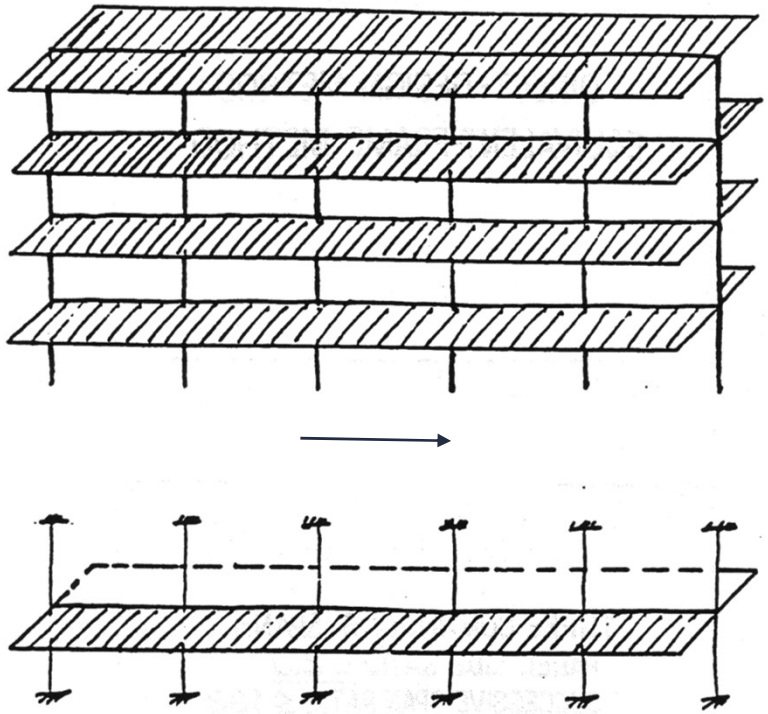


(Source: Nilson, A., Darwin, D., and Dolan, C., *Design of Concrete Structures*, McGraw-Hill, 2009)

Orthogonal Slices out of Building

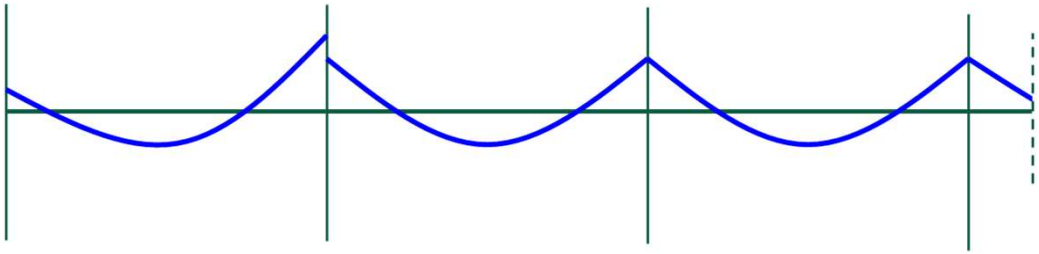


Subsystems for Lateral and Gravity Load Analysis

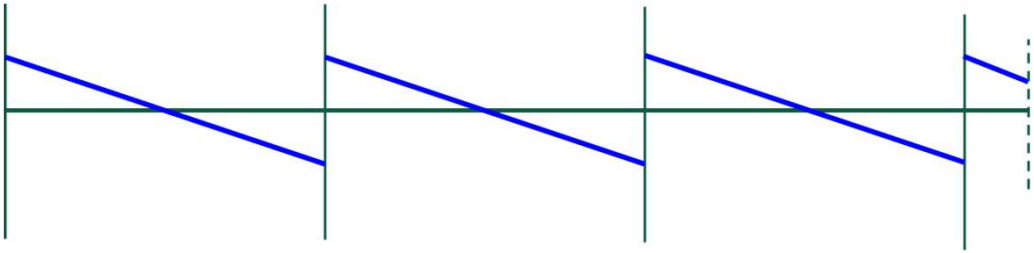


Slab Moment Distribution under Gravity and Lateral Loads

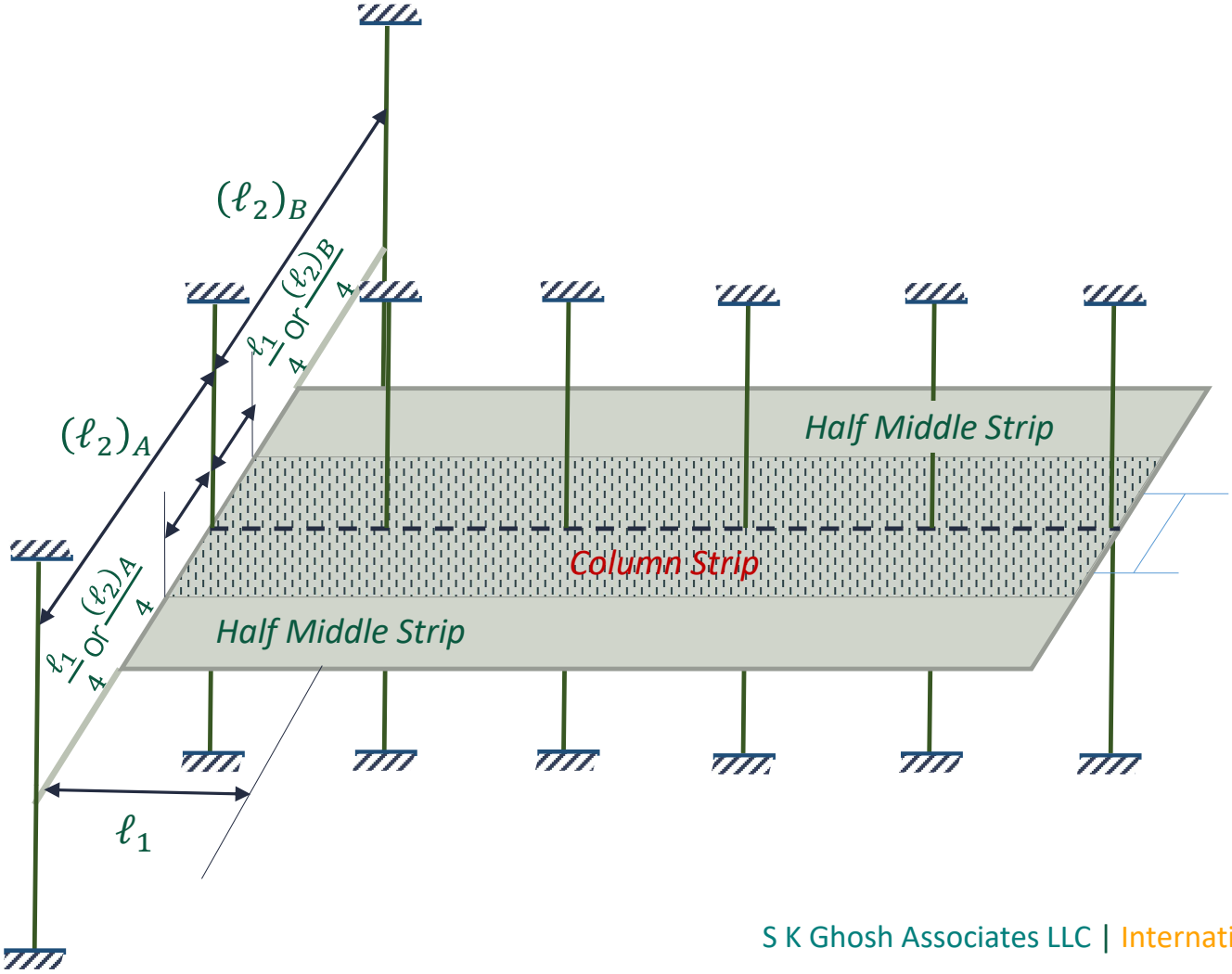
Moment distribution: gravity load



Moment distribution: lateral load



Unbalanced Moment Transfer by Flexure

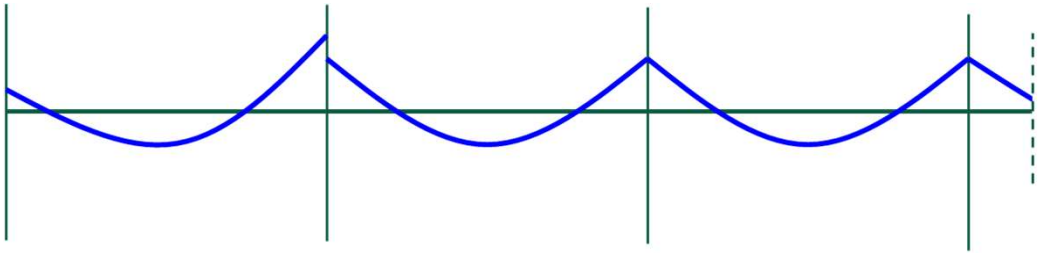


Effective width for moment transfer = c_2 +3h

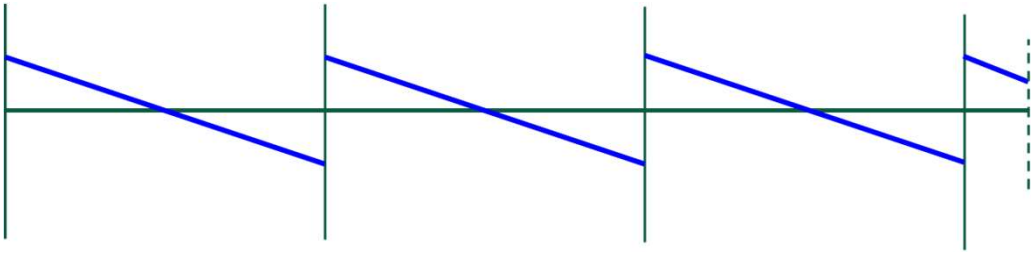
where,
c_2= column depth
h = slab thickness

Slab Moment Distribution under Gravity and Lateral Loads

Moment distribution: gravity load



Moment distribution: lateral load



Unbalanced Moment Transfer by Flexure

ACI 318-11 ACI 13.5.3.2. A fraction of the unbalanced moment given by $\gamma_f M_u$ shall be considered to be transferred by flexure within an effective slab width between lines that are one and one-half slab or drop panel thickness (1.5h) outside opposite faces of the column or capital, where M_u is the factored moment to be transferred and

$$\gamma_f = \frac{1}{1+(2/3)\sqrt{b_1/b_2}}$$

Unbalanced Moment Transfer by Flexure

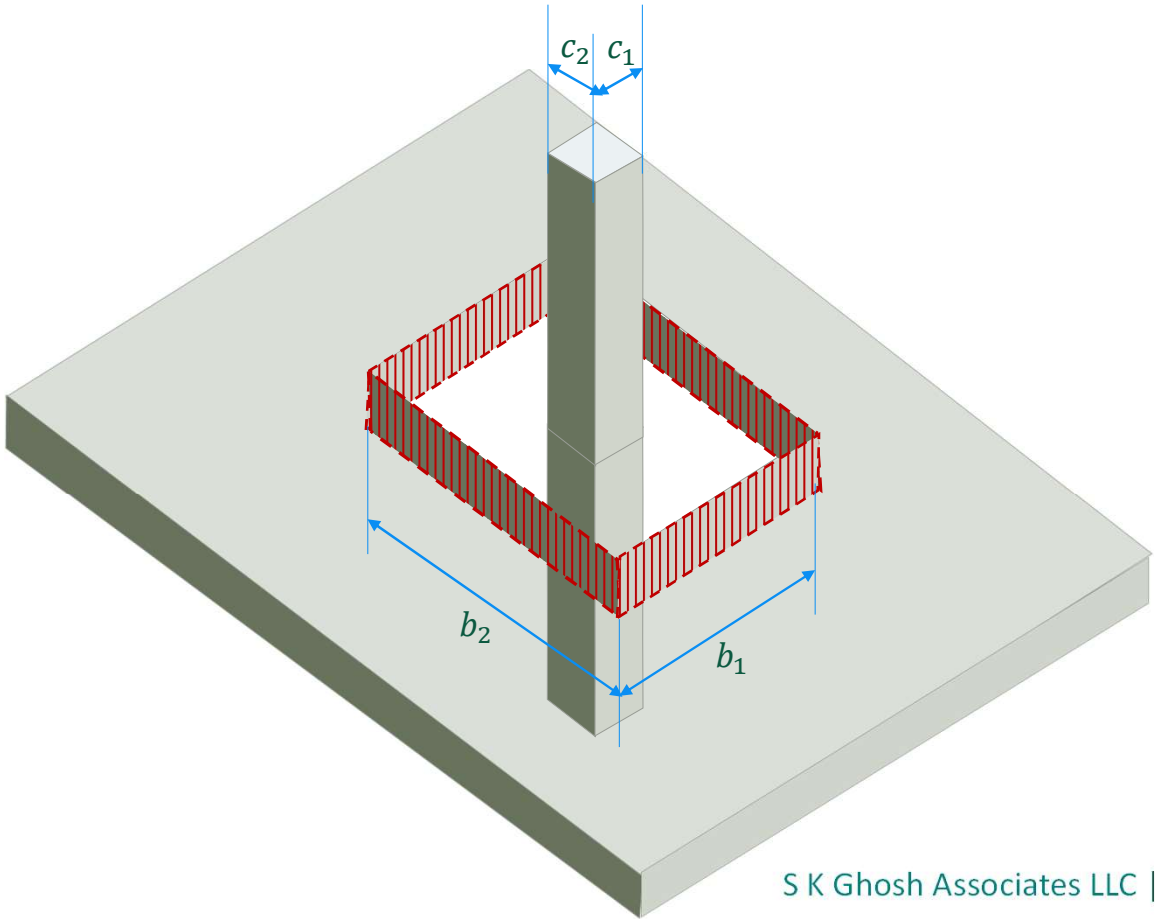
ACI 318-71 $\gamma_f = \dfrac{1}{1+\frac{2}{3}\sqrt{\frac{c_1+d}{c_2+d}}}$

ACI 318-77 unchanged

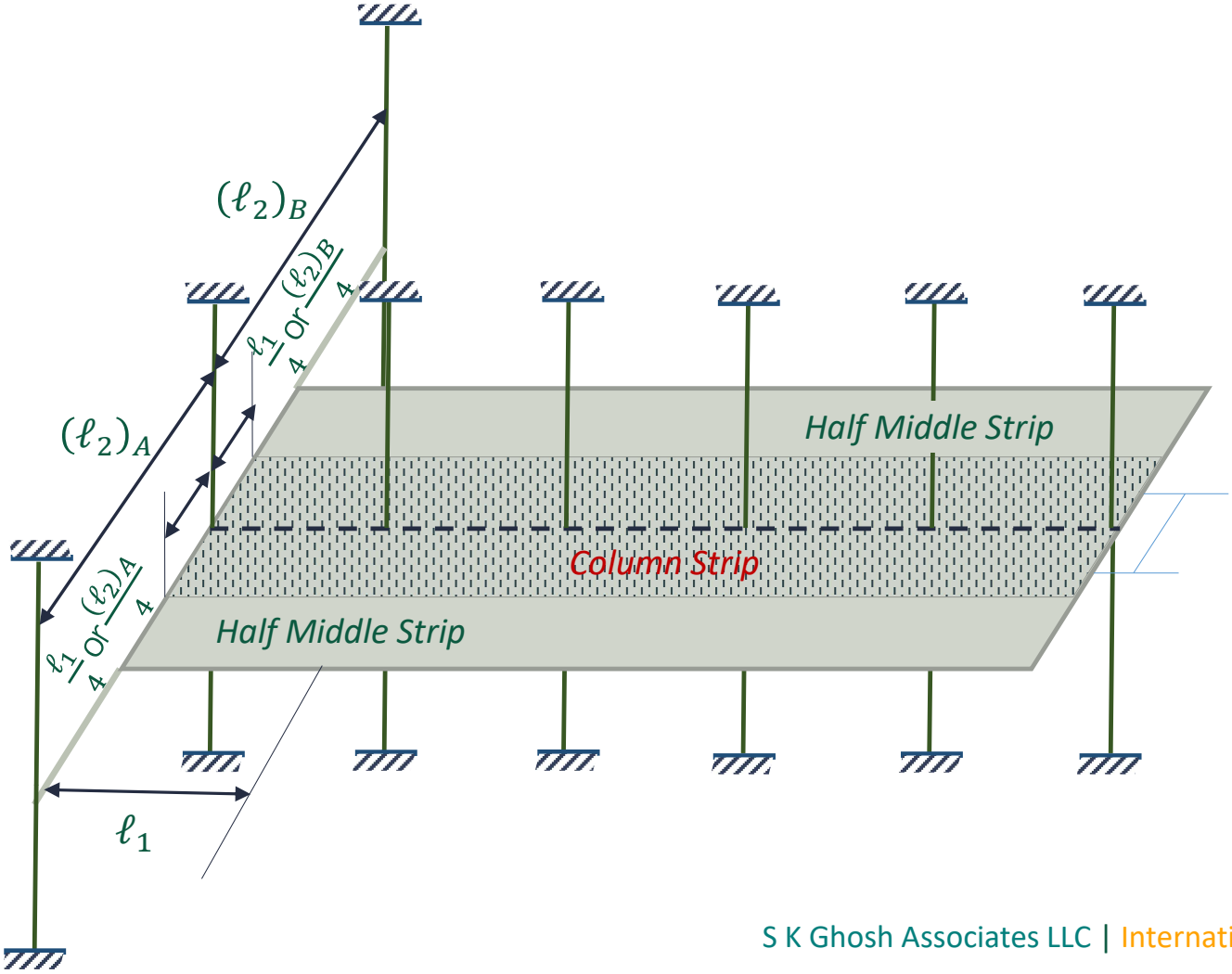
ACI 318-83 unchanged

ACI 318-89 $\gamma_f = \dfrac{1}{1+\frac{2}{3}\sqrt{\frac{b_1}{b_2}}}$

Critical Section



Unbalanced Moment Transfer by Flexure



Effective width for moment transfer = c_2 +3h

where,
c_2= column depth
h = slab thickness

Width of Moment Transfer Band

ACI 318-71

13.2.4 - … A slab width between lines that are one-half slab or drop panel thickness, *h*/2, on each side of the column or capital may be considered effective.

Width of Moment Transfer Band

ACI 318-77

ACI 318-83, 318-89 (13.3.3.2, 13.3.3.3)

318-95, 318-99, 318-02, 318-05, 318-08, 318-11 (13.5.3.2)

ACI 318-14 (8.4.2.3.3)

13.3.4.2 – A fraction of unbalanced moment given by [γ_f] shall be transferred by flexure over an effective slab width between lines that are one and one-half slab or drop panel thickness (1.5*h*) outside opposite faces of the column or capital.

13.3.4.3 – Concentration of reinforcement over the column by closer spacing or additional reinforcement may be used to resist moment on the effective slab width defined in Section 13.3.4.2.

Width of Moment Transfer Band

ACI 318-19

Table 8.4.2.2.3—Dimensional limits for effective slab width

	Distance on each side of column or capital	
Without drop panel or shear cap	Lesser	1.5*h* of slab
		Distance to edge of slab
With drop panel or shear cap	Lesser	1.5*h* of drop or cap
		Distance to edge of the drop or cap plus 1.5*h* of slab

Flexibility in Unbalanced Moment Transfer – Flexure vs. Shear

An IMPORTANT ACI 318-95 Change

ACI 318-11 13.5.3.3 — For nonprestressed slabs with unbalanced moments transferred between the slab and columns, it shall be permitted to increase the value of γ_f given by Eq. (13-1) in accordance with the following:

(a) For edge columns with unbalanced moments about an axis parallel to the edge, $\gamma_f = 1.0$ provided that V_u at an edge support does not exceed $0.75\phi Vc$, or at a corner support does not exceed $0.5\phi V_c$.

Basis of 1995 ACI 318 Change

Code procedures, history, and shortcomings

Column-Slab Connections

by Jacob S. Grossman

Concrete International

September 1989

ACI Fellow **Jacob S. Grossman** is partner in charge of design and research in Robert Rosenwasser Associates PC, Consulting Structural Engineers, New York City. The firm specializes in high-rise construction. He is a member of the Concrete Material Research Council; the Reinforced Concrete Research Council; and ACI Committees 318, Standard Building Code; 435, Deflection of Structures; and 442, Response to Lateral Forces. He also has served on the ACI Board of Direction. In 1987 he received ACI's Maurice P. van Buren Structural Engineering Award and in 1989 he was given ACI's Alfred E. Lindau Award.

Flexibility in Unbalanced Moment Transfer – Flexure vs. Shear

An IMPORTANT ACI 318-95 Change

ACI 318-11 13.5.3.3 (Contd.) —

(b) For unbalanced moments at interior supports, and for edge columns with unbalanced moments about an axis perpendicular to the edge, increase γ_f to as much as 1.25 times the value from Eq. (13-1), but not more than $\gamma_f = 1.0$, provided that V_u at the support does not exceed $0.4\phi Vc$. The net tensile strain ε_t calculated for the effective slab width defined in 13.5.3.2 shall not be less than 0.010.

The value of V_c in items (a) and (b) shall be calculated in accordance with 11.11.2.1.

Flexibility in Unbalanced Moment Transfer – Flexure vs. Shear

ACI 318-89 R13.5.3.3 - The 1989 code procedures remain unchanged, except that under certain conditions the designer is permitted to adjust the level of moment transferred by shear without revising member sizes. Recent evaluation of available tests indicate that some flexibility in distribution of unbalanced moments transferred by shear and flexure at both exterior and interior supports is possible. Changes in the 1995 Code were made to recognize, to some extent, design practices prior to the 1971 code. [Grossman, 1989]

Flexibility in Unbalanced Moment Transfer – Flexure vs. Shear

ACI 318-89 R13.5.3.3 (Contd.) - At exterior supports, for unbalanced moments about an axis parallel to the edge, the portion of moment transferred by eccentricity of shear $Y_v M_u$ may be reduced provided that the factored shear at the support (excluding the shear produced by moment transfer) does not exceed 75 percent of the shear capacity φV_c as defined in 11.12.2.1 for edge columns or 50 percent for corner columns. Tests indicate that there is no significant interaction between shear and unbalanced moment at the exterior support in such cases [Moehle, 1988; ACI-ASCE Committee 352, 1988]. Note that as $Y_v M_u$ is decreased $Y_f M_u$ is increased.

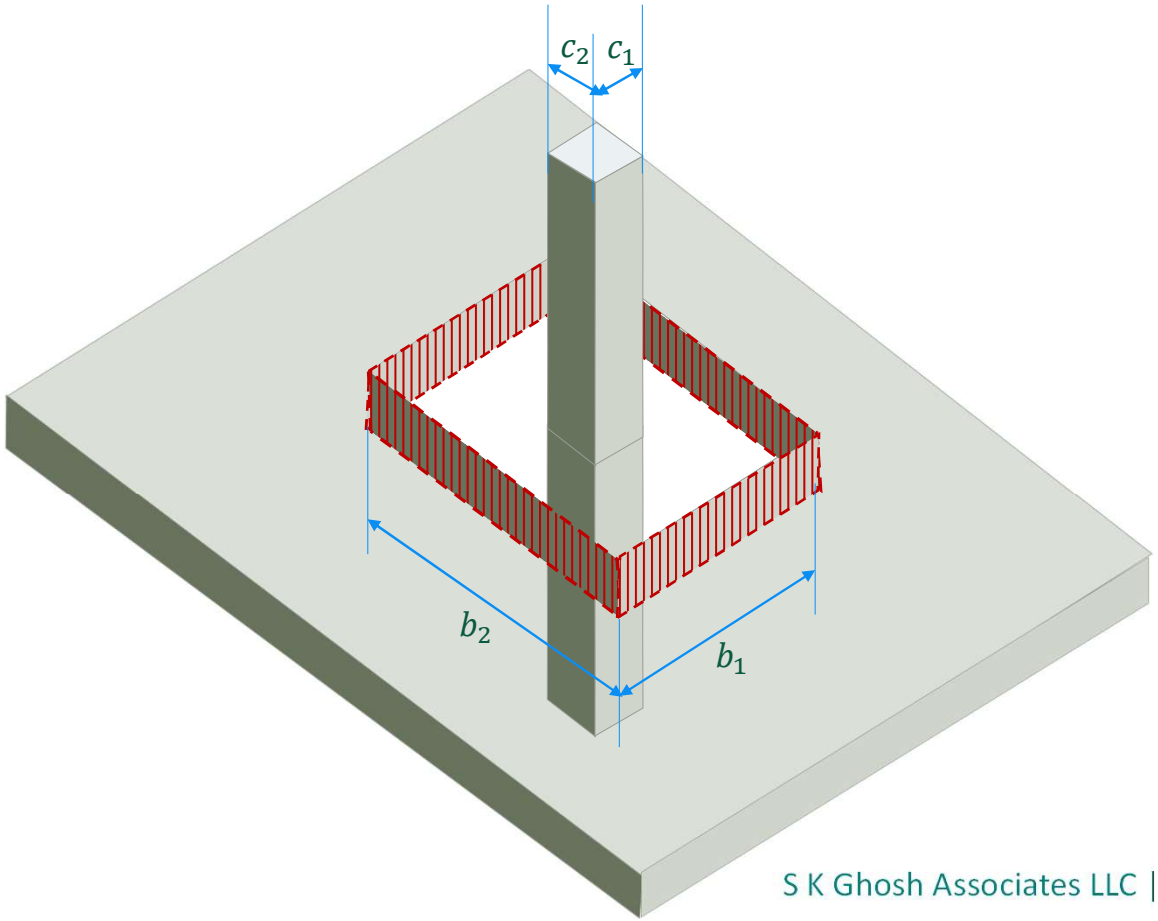
Flexibility in Unbalanced Moment Transfer – Flexure vs. Shear

ACI 318-89 R13.5.3.3 (Contd.) - Evaluation of tests of interior supports indicates that some flexibility in distributing unbalanced moments by shear and flexure is also possible, but with more severe limitations than for exterior supports. For interior supports, the unbalanced moment transferred by flexure is permitted to be increased up to 25 percent provided that the factored shear (excluding the shear caused by the moment transfer) at the interior supports does not exceed 40 percent of the shear capacity φV_c as defined in 11.12.2.1.

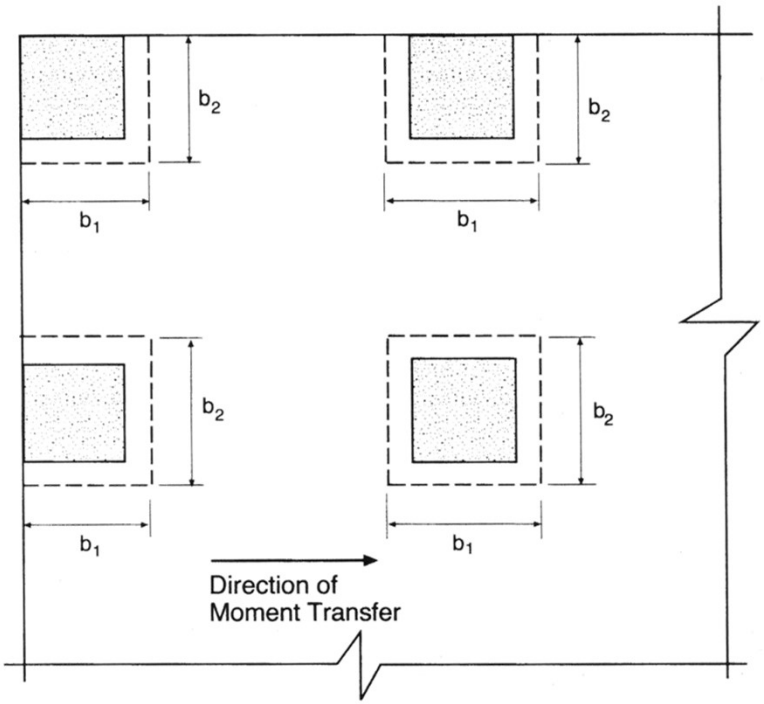
Flexibility in Unbalanced Moment Transfer – Flexure vs. Shear

ACI 318-89 R13.5.3.3 (Contd.) - Tests of slab-column connections indicate that a large degree of ductility is required, because the interaction between shear and unbalanced moment is critical. When the factored shear is large, the column-slab joint cannot always develop all of the reinforcement provided in the effective width. The modifications for edge, corner, or interior slab column connections specified in 13.5.3.3 are permitted only when the reinforcement ratio (within the effective width) required to develop the unbalanced moment $y_f M_u$ does not exceed $O.375\rho_b$. The use of Eq. (13-1), without the modification permitted in 13.5.3.3, will generally indicate overstress conditions on the joint. The provisions of 13.5.3.3 are intended to improve ductile behavior of the column-slab joint. When a reversal of moments occurs at opposite faces of an interior support, both top and bottom reinforcement should be concentrated within the effective width. A ratio of top to bottom reinforcement of about 2 has been observed to be appropriate.

Critical Section



Critical Section for Two-Way Shear



Parameters b_1 and b_2

(Source: Portland Cement Association, *Notes on ACI 318-08 Building Code Requirements for Structural Concrete*, Skokie, IL, 2008)

Critical Section for Two-Way Shear

ACI 318-71

11.10.2 – The critical section for two-way action shall be perpendicular to the plane of the slab and located so that its periphery is a minimum and approaches no closer than d/2 to the periphery of the concentrated load or reaction area.

ACI 318-77, 318-83

11.11.2 – Substantially the same

Critical Section for Two-Way Shear

ACI 318-89, 318-95, 318-99, 318-02, 318-05

ACI 318-08, 318-11 (11.11.1.2, 11.11.1.3)

ACI 318-14, 318-19 (22.6.4.1, 22.6.4.1.1)

11.12.1.2 - Two-way action where each of the critical sections to be investigated shall be located so that its perimeter b_o is a minimum but need not approach closer than *dl2* to

(a) edges or corners of columns, concentrated loads, or reaction areas, or

(b) changes in slab thickness such as edges of capitals or drop panels.

11.12.1.3 - For square or rectangular columns, concentrated loads, or reaction areas, the critical sections with four straight sides shall be permitted.

Transfer of Moment at Slab-Column Connections

The total shear stress due to direct shear and shear caused by moment transfer is

$$v_u = \frac{V_u}{A_c} + \frac{\gamma_v M_u c}{J}$$

where

V_u = direct shear at the critical section

A_c = area of critical section

Transfer of Moment at Slab-Column Connections

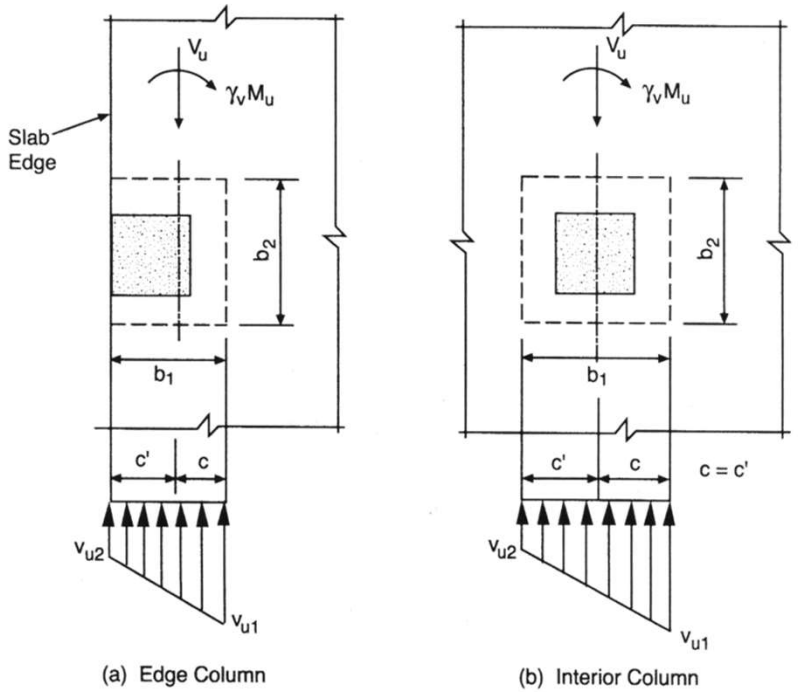
γ_v = factor used to determine the unbalanced moment transferred by eccentricity of shear at slab-column connections

M_u = unbalanced moment

c = distance from centroid of critical section to face of section where stress is being computed

J = property of critical section analogous to polar moment of inertia

Transfer of Moment at Slab-Column Connections



Shear stress distribution due to moment-shear transfer at slab-column connections

(Source: Portland Cement Association, *Notes on ACI 318-08 Building Code Requirements for Structural Concrete*, Skokie, IL, 2008)

Strength Design - Shear

$$v_u \leq \varphi v_n$$

$$\varphi = 0.75$$

Two-Way Shear Strength of Concrete

ACI 318-71	$v_n = \frac{V_c}{b_o d} = 4\sqrt{f_c'}$	No provision for shear reinforcement
ACI 318-77 **ACI 318-83**	$v_n = \frac{V_c}{b_o d} = \left(2 + \frac{4}{\beta_c}\right)\sqrt{f_c'} \leq 4\sqrt{f_c'}$	No provision for shear reinforcement β_c = ratio of long side to short side of column

Two-Way Shear Strength of Concrete

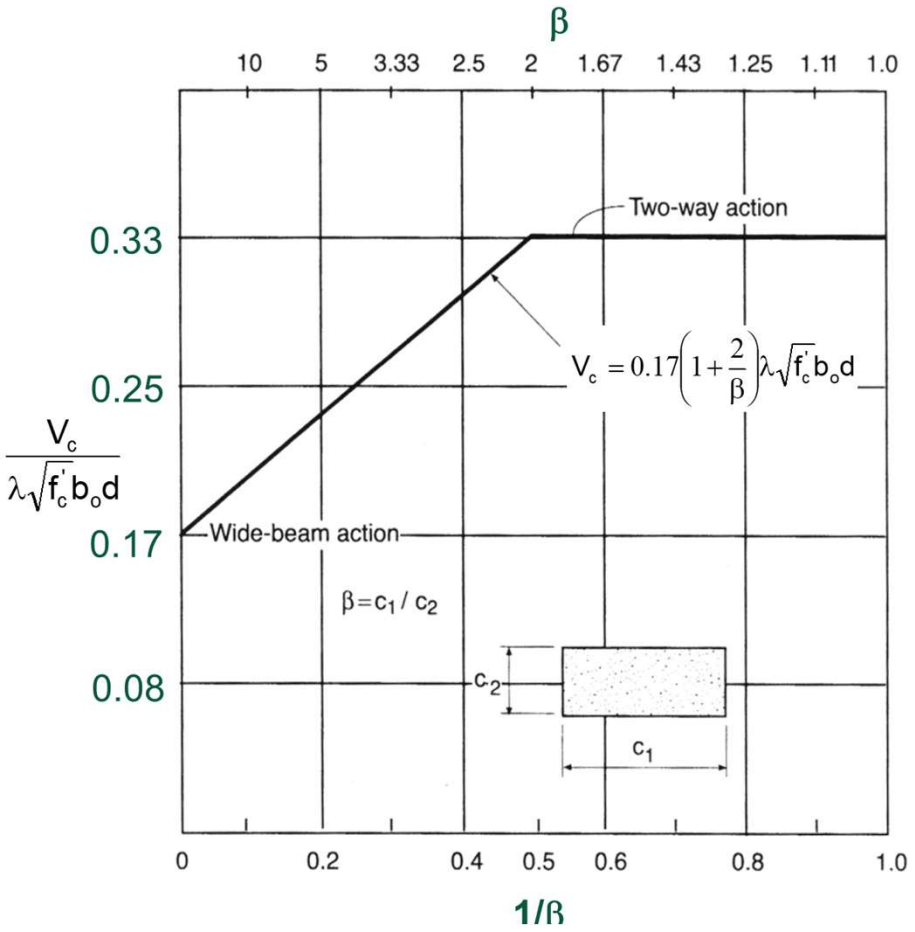
ACI 318-89 **ACI 318-95** **ACI 318-99** **ACI 318-02** **ACI 318-05**	$v_n = V_c/b_o d$ is the smallest of $(2 + 4/\beta_c)\sqrt{f_c'}$ $(\alpha_s d/b_o + 2)\sqrt{f_c'}$ $4\sqrt{f_c'}$	**Without shear reinforcement** α_s is 40 for interior columns, 30 for edge columns, and 20 for corner columns
	$v_n = V_c/b_o d = (V_c + V_s)/b_o d$ $= (2\sqrt{f_c'} + A_v f_y d/s) \leq 6\sqrt{f_c'}$	**With conventional shear reinforcement** A_v shall be taken as the cross-sectional area of all legs of reinforcement on one peripheral line that is geometrically similar to the perimeter of the column section.
	$v_n = V_c/b_o d = 2\sqrt{f_c'}$	**Beyond where shear reinforcement is discontinued**

Two-Way Shear Strength of Concrete

ACI 318-08	In addition to above, $v_n = V_c/b_o d = (V_c + V_s)/b_o d$ $= (2\sqrt{f_c'} + A_v f_y d/s) \leq 8\sqrt{f_c'}$ $v_n = V_c/b_o d = 2\sqrt{f_c'}$	**With headed shear stud reinforcement** A_v is the cross-sectional area of all the shear reinforcement on one peripheral line that is approximately parallel to the perimeter of the column section, where $\boldsymbol{s}$ is the spacing of the peripheral lines of headed shear stud reinforcement. **Beyond where shear reinforcement is discontinued**

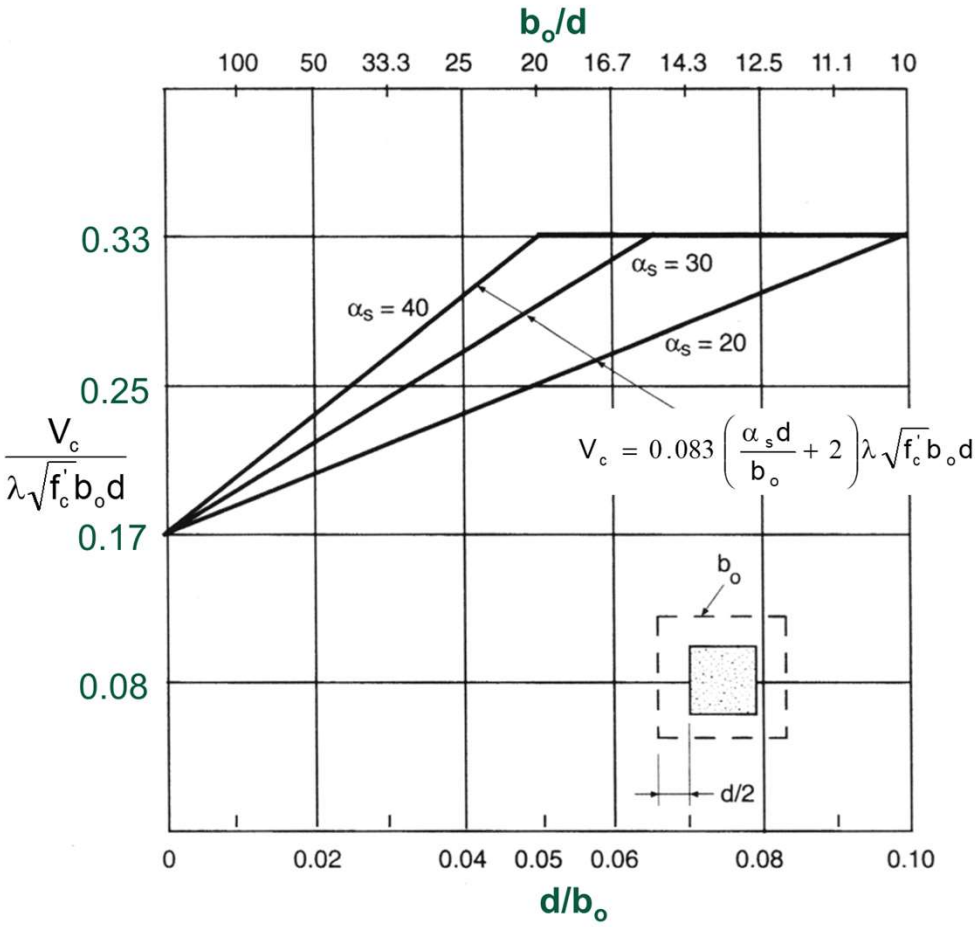
Concrete Shear Strength for Two-Way Action in the Absence of Shear Reinforcement

Effect of *b* on two-way shear strength V_c
(Source: Portland Cement Association, *Notes on ACI 318-08 Building Code Requirements for Structural Concrete*, Skokie, IL, 2008)



Concrete Shear Strength for Two-Way Action in the Absence of Shear Reinforcement

Effect of *bo/d* on two-way shear strength V_c
(Source: Portland Cement Association, *Notes on ACI 318-08 Building Code Requirements for Structural Concrete*, Skokie, IL, 2008)



In Numerical Terms …

For f_c' = 4000 psi, $v_c = 4\sqrt{f_c'}$ = 265 psi

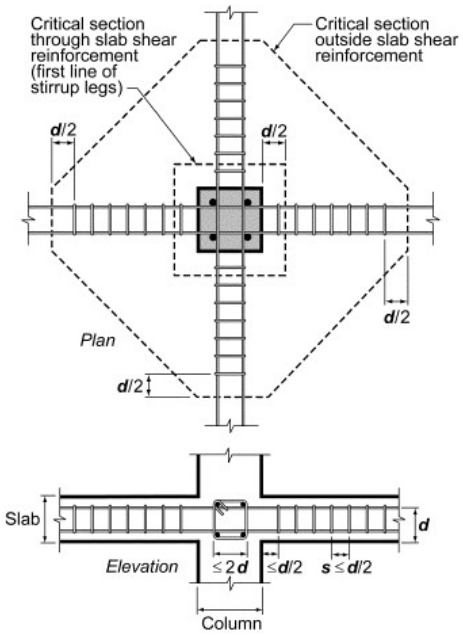
At a column with a long-to-short side ratio of 3,
$v_c = (2 + 4/3)\sqrt{f_c'} = 3.33\sqrt{f_c'}$ = 221 psi, a 16-1/2% decrease.

ACI 318-56: v_c = 100 psi if 50% column strip reinforcement placed within column strip

= 85 psi if 25% column strip reinforcement placed within column strip

Conventional Punching Shear Reinforcement

Provisions for conventional punching shear reinforcement introduced in ACI 318-89. Maximum $V_n/b_o d$ went up from $4\sqrt{f_c'}$ to $6\sqrt{f_c'}$.



Conventional Punching Shear Reinforcement

Provisions for headed shear stud punching sear reinforcement introduced in ACI 318-08. Maximum $V_n/b_o d$ went up from $4\sqrt{f_c'}$ to $8\sqrt{f_c'}$.

Minimum Flexural Reinforcement in Non-prestressed Slabs

8.6.1.1 A minimum area of flexural reinforcement, $A_{s,min}$ of $0.0018A_g$, or as defined in 8.6.1.2, shall be provided near the tension face of the slab in the direction of the span under consideration ~~in accordance with Table 8.6.1.1.~~

Minimum Flexural Reinforcement in Non-prestressed Slabs

8.6.1.2 If $v_{uv} > \phi 2\lambda_s \lambda \sqrt{f'_c}$ on the critical sections for two-way shear surrounding a column, concentrated loads, or reaction areas, $A_{s,min}$, provided over the width b_{slab} shall satisfy Eq 8.6.1.2

$$A_{s,min} = \frac{5 v_{uv} b_{slab} b_o}{\phi \alpha_s f_y} \qquad (8.6.1.2)$$

Minimum Flexural Reinforcement in Non-prestressed Slabs

R8.6.1.2 (Contd.) Tests on interior column-to-slab connections with lightly reinforced slabs with and without shear reinforcement have shown that yielding of the slab flexural tension reinforcement in the vicinity of the column or loaded area leads to increased local rotations and opening of any inclined crack existing within the slab. In such cases, sliding along the inclined crack can cause a flexure-driven punching shear failure at a shear force less than the strength calculated by the two-way shear equations of Table 22.6.5.2 for slabs without shear reinforcement and less than the strength calculated in accordance with 22.6.6.3 for slabs with shear reinforcement.

Minimum Flexural Reinforcement in Non-prestressed Slabs

R8.6.1.2 (Contd.) Tests of slabs with flexural reinforcement less than $A_{s,min}$ have shown that shear reinforcement does not increase the punching shear strength. However, shear reinforcement may increase plastic rotations prior to the flexure-driven punching failure.

Minimum Flexural Reinforcement in Non-prestressed Slabs

R8.6.1.2 (Contd.) Inclined cracking develops within the depth of the slab at a shear stress of approximately $2\lambda_s\lambda\sqrt{f_c'}$. At higher shear stresses, the possibility of a flexure-driven punching failure increases if $A_{s,min}$ is not satisfied. $A_{s,min}$ was developed for an interior column, such that the factored shear force on the critical section for shear equals the shear force associated with local yielding at the column faces.

Minimum Flexural Reinforcement in Non-prestressed Slabs

R8.6.1.2 (Contd.) To derive Eq. (8.6.1.2) the shear force associated with local yielding was taken as $8A_{s,min}\,f_y d/b_{slab}$ for an interior column connection (Hawkins and Ospina 2017) and generalized as $\alpha_s/5)A_{s,min}\,f_y d/b_{slab}$ to account for edge and corner conditions. $A_{s,min}$ also needs to be provided at the periphery of drop

panels and shear caps.

ACI 318-71 Unbalanced Moment Transfer Provision

ACI 318-71 13.2.4 – When unbalanced gravity load, wind, earthquake, or other lateral loads cause transfer of bending moment between slab and column, the flexural stresses on the critical section shall be investigated by analysis, and the cross section proportioned according to the requirements of Section 11.13.2. Concentration of reinforcement over the column head by closer spacing or additional reinforcement may be used to resist the moment on this section. A slab width between lines that are one-half slab or drop panel thickness, $h/2$, on each side of the column or capital may be considered effective.

ACI 318-71 Unbalanced Moment Transfer Provision

ACI 318-71 11.13.2 - When unbalanced gravity load, wind, earthquake, or other lateral loads cause transfer of bending moment between slab and column, a fraction of the moment given by

$$\left(1 - \frac{1}{1 + \frac{2}{3}\sqrt{\frac{c_1 + d}{c_2 + d}}}\right)$$

Shall be considered transferred by eccentricity of the shear about the centroid of the critical section defined in Section 11.10.2. Shear stresses shall be taken as varying linearly about the centroid of the critical section and the shear stress v_u shall not exceed $4\sqrt{f_c'}$.

Thank you for participating!

File Attachments for Item:

EC-13 Understanding Emergency Responder Communication Enhancement Systems Codes and Technology (Koorsen Fire and Security)

All certifications (1 hour)

Emergency Responder Communication Enhancement Systems (BDA)

This presentation will discuss the evolution of code requirements, NFPA 72 and 1221 and IBC / IFC code along with UL 2524 requirements. We will dive into how and when to perform Signal testing per NFPA and IFC and if a BDA is required how that would get deployed. Predictive Signal or Heat Map design will be discussed along with the equipment used. Lastly we will discuss some general code questions related to Conduit and 2 hour requirements for these systems. Questions will be answered during the presentation and total time should be less than 1.5 hr.

Presenter Bio

David Thompson

David has been in the life safety world since 1997. Starting with Simplex he has worked for JCI (prior to Simplex acquisition) spending a few years with a small life safety company in Evansville IN. He began his time with Koorsen Fire and Security in 2004 until 2016 doing System Sales including Security, Fire Suppression (Clean Agent) Security, Access Control CCTV and Sound / Intercom. In 2016 David went to Honeywell as a Regional Manager for the Midwest managing Gamewell FCI Fire Alarm. In 2019 Honeywell tasked his as Nation Business Development for the new BDA product line they introduced and he was in that role until coming back to Koorsen in November 2021 to help grow BDA business and manage overall Fire Alarm sales.

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: David Thompson

Organization: Koorsen Fire and Security

Address: 2719 N Arlington Ave Indianapolis IN 46218

E-mail: david.thompson@koorsen.com Telephone: 463-249-0944

Website: www.koorsen.com

Conference Sponsor (if applicable) _____ Conference Email: _____

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Understanding Emergency Responder Communication Enhancement Systems Codes and Technology

Course instructor: David Thompson

Course description: In depth presentation of the Codes and Implementtation for Emergency Responder Communication Enhancment Systems Class will discuss International Fire Code, International Buidling Code, NFPA 72, NFPA 1221 / 1225. FCC part 90 and UL 2524 requirements. Discuss of the hardware and the design software and survey options and equipment. Also discussion of how to create local guidelines as required by NFPA

Instructional hours per session: 1 Number of Sessions: 1

Course Date(s) and Location: Would like to approve for the Joint Conference in November or any local chapter training

Special Content:

Code Administration: ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☐

Commercial Certifications: ☑

Application materials included:

☐ Course Outline or Course Learning Objectives
☐ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

We will be starting shortly

Thank you for joining us!

BDA / ERCES Systems

David Thompson
Corporate Fire Alarm &
Communications Sales Manager

May 2022

Fire Code Terminology NFPA 72 / 1221 IBC – Commonly Used

Emergency Radio (Responder) Communication Enhancement Systems - ERCES
In-Building Emergency Responder Radio Systems - IBERRS
In-building public safety radio signal booster - IBPSRSB
In-building radio system -IBRS
In building emergency communication radio enhancement systems – IBECRES
In-building emergency responder radio enhancement system – IBERRES
In-Building Public Safety Communication Systems - IBPSCS

Auxiliary Radio Communication | ARC System (in New York City & Long Island)

Public safety signal booster – PSSB
Public safety in-building communications systems - PSIBCS
Public safety bi directional amplifier – PSBDA
Public safety radio enhancement system – PSRES

Emergency radio coverage system - ERCS
Emergency Communications Radio System – ECRS
Emergency responder radio coverage systems – ERRCS

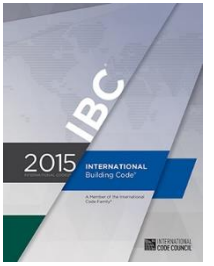
Signal booster system – SBS
Distributed antenna system –DAS
2-way radio communication enhancement systems – RCES

BDA Life Safety Benefits of BDA Systems

Codes & Standards

1150

Code-Driven Requirement

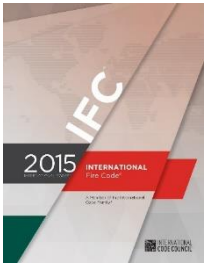


IBC 2015 - Section 916 NFPA 1 – Section 11.10
Refers to IFC section 510 or the state recognized fire code

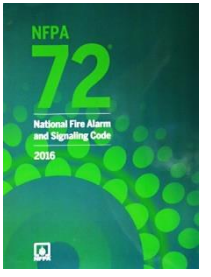
IFC Section 510 Emergency Responder Radio Coverage

First appeared in the appendix of the 2009 IFC, the provision was moved to the body of the code in 2012

All of the States Koorsen Covers use IBC / IFC



Section 1103.2 of IFC specifies the requirements for emergency responder radio coverage in existing buildings



NFPA 72 National Fire Alarm and Signaling Code
2010 / 2013 Edition, section 24.5.2
The 2016 /2019 edition of NFPA 72 relocated the requirements to NFPA 1221
NFPA 1221, Section 9.6 is a Life-Safety Code
NFPA 1225 2022 Edition. Standard for Emergency Services Communication

Indiana Amendment IBC 915

(jjj) Delete Section 915, Emergency Responder Radio Coverage, without substitution. *(Fire Prevention and Building Safety Commission; 675 IAC 13-2.6-10; filed Aug 1, 2014, 11:12 a.m.: 20140827-IR-675130339FRA, eff Dec 1, 2014; errata filed Aug 7, 2014, 8:54 a.m.: 20140827-IR-675130339ACA)*

Indiana is the only state to delete this section of International Building Code

However it can be enforced by local jurisdiction

Indiana is on a Code Cycle based on 2018 IFC

IFC 2015 / 2012 Requirements New Buildings

510.1 Emergency responder radio coverage in new buildings.
All new buildings shall have approved radio coverage for emergency responders within the building based upon the existing coverage levels of the public safety communication systems of the jurisdiction at the exterior of the building. This section shall not require improvement of the existing public safety communication systems.

Exceptions:
Where *approved* by the building official and the *fire code official*, a wired communication system in accordance with Section 907.2.13.2 shall be permitted to be installed or maintained instead of an *approved* radio coverage system.

Where it is determined by the *fire code official* that the radio coverage system is not needed.

In facilities where emergency responder radio coverage is required and such systems, components or equipment required could have a negative impact on the normal operations of that facility, the *fire code official* shall have the authority to accept an automatically activated emergency responder radio coverage system.

IFC 2015 / 2012 Requirements Existing Buildings

1103.2 Emergency responder radio coverage in existing buildings.
Existing buildings that do not have approved radio coverage for emergency responders within the building, based upon the existing coverage levels of the public safety communication systems of the jurisdiction at the exterior of the building, shall be equipped with such coverage according to one of the following:

1. Where an existing wired communication system cannot be repaired or is being replaced, or where not approved in accordance with Section 510.1, Exception 1.

2. Within a time frame established by the adopting authority.

Exception: Where it is determined by the fire code official that the radio coverage system is not needed.

2015 IFC 510 / NFPA Coverage Requirements

510.4.1 Radio signal strength.
The building shall be considered to have acceptable emergency responder radio coverage when signal strength measurements in 95 percent of all areas on each floor of the building meet the signal strength requirements in Sections 510.4.1.1 and 510.4.1.2.

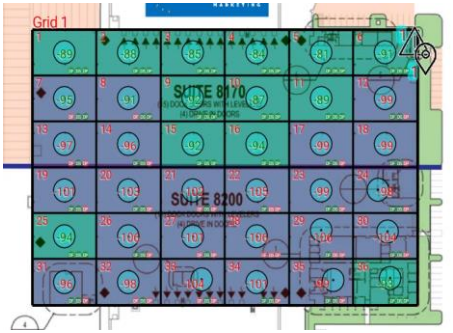
510.4.1.1 Minimum signal strength into the building.
A minimum signal strength of **-95 dBm** shall be receivable within the building.

510.4.1.2 Minimum signal strength out of the building.
A minimum signal strength of **-95 dBm** shall be received by the agency's radio system when transmitted from within the building.

Downlink Signal Test using the PC Tel

Radio signal strength as measured by RSSI / BER / SNR

This test is conducted using the PC Tel tool per each Grid of the building floors. Technicians in each branch have been trained to use this tool and perform this test.



2016 / 2019 NFPA 1221 Coverage Requirements

Radio signal strength.
The building shall be considered to have acceptable emergency responder radio coverage when signal strength measurements in 90 percent of all areas on each floor of the building meet the signal strength requirements

9.6.8.1 Minimum signal strength into the building.
A minimum signal capability of DAQ 3.0 shall be receivable within the building.

9.6.8.2 Minimum signal strength out of the building.
A minimum signal capability of DAQ 3.0 shall be receivable within the building.

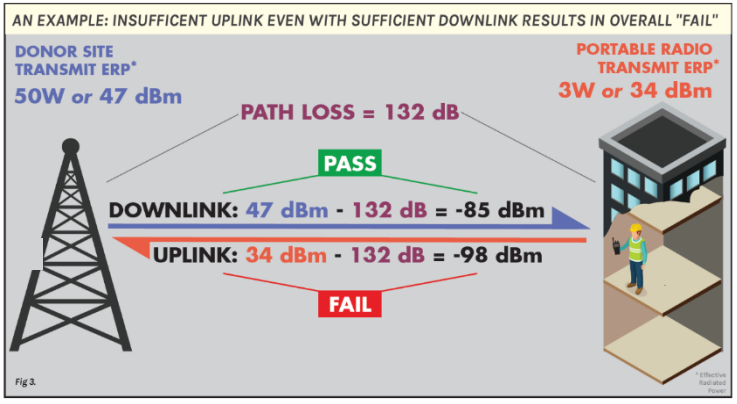
DAQ	Definition
1	Unusable. Speech present but not understandable.
2	Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.
3	Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
3.4	Speech understandable without repetition. Some noise or distortion present.
4	Speech easily understandable. Little noise or distortion.
4.5	Speed easily understandable. Rare noise or distortion.
5	Perfect. No distortion or noise discernible.

Code-Required Inbound and Outbound Signal Strength

Q: If signal strength readings are not performed at the donor site, *how can you ensure a minimum outbound signal strength of -95 dBm?*

A: Calculate outbound signal strength based on the inbound signal strength.

1. Determine the *signal strength difference* between the *donor site ERP* (effective radiated power) and the *portable radio's ERP,* typically 34 dBm
2. Then subtract the *signal strength difference* from our *in-building signal strength* reading to determine the *outbound signal strength*



-**85 dBm is the inbound signal strength** and *13 dB is the signal strength difference* (47 dBm – 34 dBm = 13 dB).
We can calculate the **outbound signal strength as -98 dBm** (-85 dBm - 13 dB = -98 dBm).
Although the minimum inbound signal strength is met**, the site survey will fail**
since the outbound signal strength is below the required -95 dBm minimum.

1159

NFPA Coverage Requirements

Critical Area Coverage – 99% (NFPA 2013 / 2016) coverage required in Critical areas:

- **Emergency Command Center(s)**
- **Fire Pump Room(s)**
- **Exit Stairs**
- **Exit Passageways**
- **Elevator Lobbies**
- **Standpipe Cabinets**
- **Sprinkler Sectional**
- **Valve Locations**
- **Elevator Cabs 2022**

General Area Coverage – General building areas should have **90%**

NFPA Requirements

Dedicated Monitoring Panel

A dedicated monitoring panel shall be provided within the emergency command center to annunciate the status of any signal booster(s). The monitoring panel shall provide visual and labeled indication of the following for each signal booster:

- Normal AC power
- Signal booster trouble
- Loss of normal AC power
- Failure of battery charger
- Low-battery capacity
- Antenna failure
- **THESE SAME POINTS SHALL ALSO BE SUPERVISED BY FIRE PANEL!**

1161

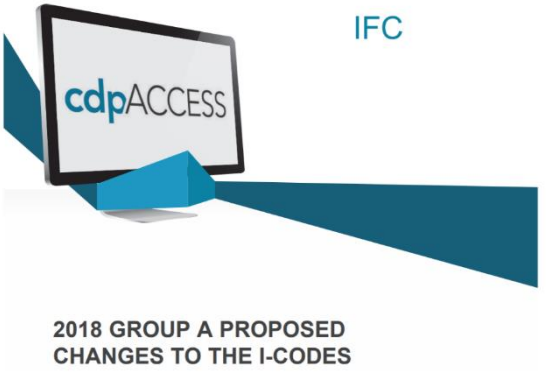
How do you know that the product was Listed for the Intended Purpose?

NFPA 1221 → NFPA 72 Chapter 10.3.1
NEC → 110.2 AND 110.3

"The equipment constructed and installed in conformity with this code shall be listed for the purpose for which it is used."
"Equipment shall only be approved if it is listed"
Listed is different than complies with, meets requirements of and certified to. AHJ should contact any lab that is not UL.

2021 ICC Requires UL 2524

2021 IFC, IBC, and NFPA 1 will all require BDA Systems to comply with UL 2524 & listed by an OSHA-accredited Nationally Recognized Testing Laboratory (NRTL)



F48-18
IFC: 510.4, 80
Proponent: Michael O'Brian, Chair, representing FCAC (FCAC@iccsafe.org)

2018 International Fire Code

Revise as follows:

510.4 Technical requirements. Equipment required to provide emergency responder radio coverage shall be listed in accordance with UL 2524. Systems, components and equipment required to provide the emergency responder radio coverage system shall comply with Sections 510.4.1 through 510.4.2.8.

Add new standard(s) follows:

UL

Underwriters Laboratories LLC
333 Pfingsten Road
Northbrook IL 60062

UL 2524 -2018:

Outline of Investigation for In-building 2-Way Emergency Radio Communication Enhancement Systems

Reason:
This is one of 10 proposals being submitted as a package relating to technical changes proposed for Section 510. While the Fire Code Committee will consider each proposal independently, the intent is for approval of all proposals in this package which have been submitted as a correlated set of companion code change proposals.

This proposal adds a requirement to test and list equipment installed to enhance emergency responder radio coverage in buildings to ensure fire and shock safety and compliance with the performance requirements specified in IFC Section 510 and NFPA 1221.

This proposal is submitted by the ICC Fire Code Action Committee (FCAC). The FCAC was established by the ICC Board of Directors to pursue opportunities to improve and enhance assigned International Codes with regard to fire safety and hazardous materials in new and existing buildings and facilities and the protection of life and property in wildland urban interface areas. In 2017 the Fire-CAC has held 3 open meetings. In addition, there were numerous conference calls, Regional Work Group and Task Group meetings for the current code development cycle, which included members of the committees as well as any interested parties, to discuss and debate the proposed changes. Related documentation and reports are posted on the FCAC website at: https://www.iccsafe.org/codes-tech-support/cs/fire-code-action-committee-fcac/

Cost Impact
The code change proposal will increase the cost of construction .

The requirement to test and list equipment will add to the cost for required equipment installed in new or existing buildings. The cost to test and certify safe equipment should not add more than 1/2% to the total cost of this equipment.

Internal ID: 377

F48-18

Committee Action: **Approved as Submitted**

Committee Reason: This proposal was approved as it will eliminate or reduce the need to have a professional engineer to review all designs and provides an appropriate listing for such equipment. (Vote 13-1)

Assembly Motion: **NONE**

1163

UL 2524 PERFORMANCE STANDARD FOR BDA SYSTEMS

Areas Addressed by UL 2524:	**Scope:**
• Safety (risk of fire and risk of shock) requirements – construction and testing • Compliance with specific performance requirements in accordance with FC-2018 & NFPA 1221-2016 (2019) • Reliability performance requirements applicable for life safety systems – construction and testing • Product marking and installation documentation	• Cover products (e.g. repeater, transmitter, receiver, signal booster components, remote annunciators and operational consoles, power supply & battery charging system components) used for in-building 2-way radio emergency radio communication enhancement systems installed in a location to improve wireless communication at that location. • Does not cover passive RF components which are defined in UL 2524 as "any device that RF passes through that does not have an active electronic component that requires external power. This includes, antennas, splitters, couplers, coaxial cable and connectors. Passive components cannot amplify RF signals."

Performance - Operation:	**Construction:**	**Reliability:**
• Normal AC power • Visual & audible annunciation within 200 secs of fault for Loss of normal AC power, Battery charger failure, Loss of battery capacity (to 70% depletion), Donor antenna disconnection, Active RF emitting device malfunction, System component malfunction other than passive RF component which affects system performance. • Visual & audible annunciation within 24 hrs. of fault for Donor antenna malfunction	• NEMA Type 4 or 4X for all repeater, transmitter, receiver, signal booster components, external filters, and battery system components. Note: Rechargeable standby batteries are permitted to be contained in enclosures that comply with the requirements for a Type 3R. • The system shall be sufficiently modular to have the capability to support revised and/or additional system frequencies within the same frequency band of the bi-directional amplifier supplied to maintain radio system coverage as it was originally intended without the need to replace the system.	• Variable Voltage Operation Test • Variable Ambient Temperature and Humidity Tests • Component Temperatures Test • Charging Current Test • Transient Testing

Includes UL 60950 Basic Safety, IFC Section 510 - 2018, NFPA 1221 – 2016

Became an ANSI Standard October 2018

UL 2524 - Listed ERCES / BDA System

UL requires Oscillation Prevention

BDA Detects Oscillation & Reduces Gain in 5dB steps until no further oscillation

BDA Sends Trouble Signal to Fire Alarm Control Panel

BDA Indicates Trouble on Remote Annunciator / Monitor

BDA Continues normal operation with the maximum allowable gain

Address key concerns of AHJs

Zero Noise Squelch

Most BDAs normally generate a small amount of noise when idle.

The cumulative effect of all this noise raises the “noise floor” on a frequency.

Honeywell BDAs operate in “stand-by mode” and do not transmit any noise while idle.

What is the UL 2524 Product Standard?

"The UL 2524 Creates a Product Performance Standard that allows manufacturers to design and list BDA systems to"

"UL 2524 Assures AHJs, A&Es, Building Owners & Occupants that Honeywell's BDA Systems Perform the First Time and Every Time—exactly as prescribed in IFC 510.5.3 and NFPA 1221."

Public Safety Radio

**“Reliable Radio Coverage is a Necessity!
Lives Depend on It!”**

The PROBLEM:
In-Building Radio Signal Degradation

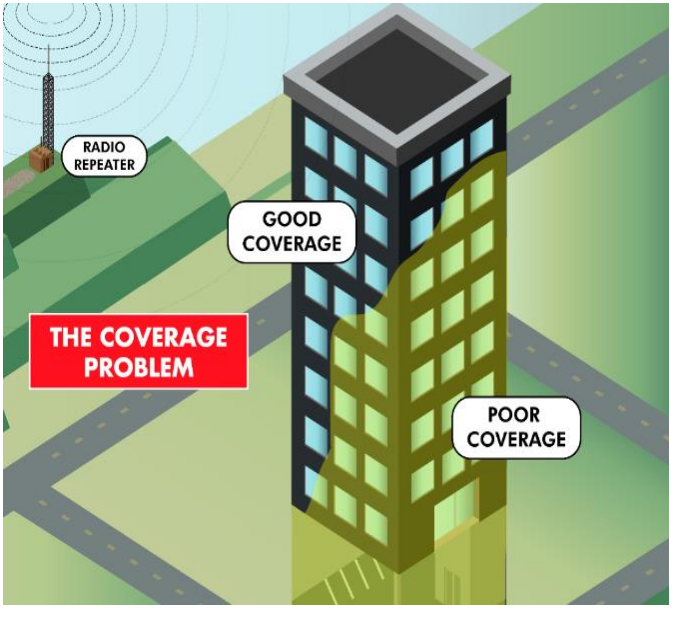
Radio signals are attenuated by:

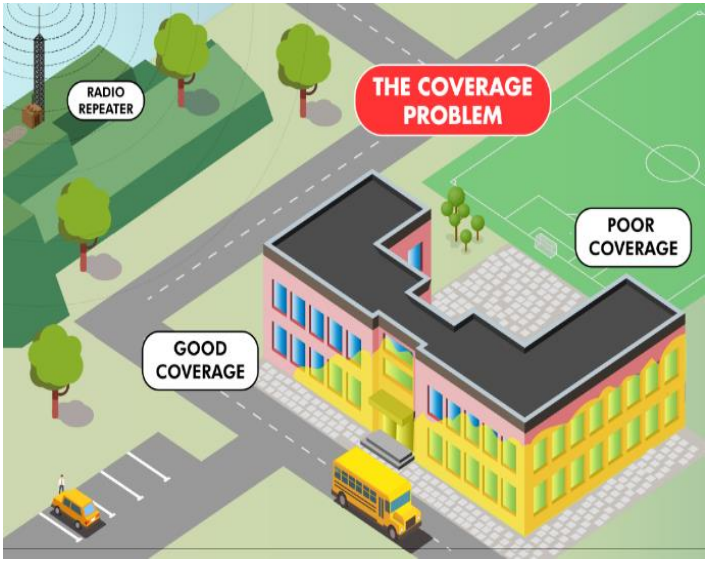
- **Concrete, Metal & Other Materials**
- **Low-E Glass**
- **Below-Ground Structures**
- **Other Obstructions**
- **Radio Frequency Interference**

The consequence:

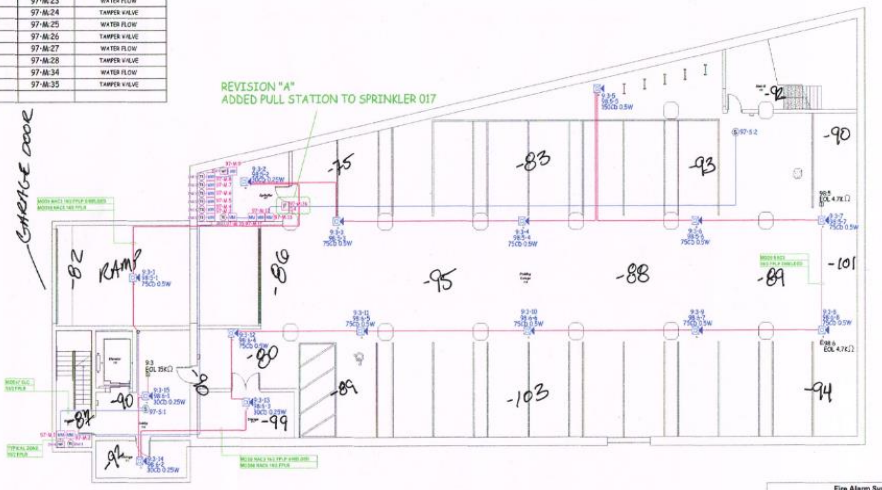
- **Poor in-building Fire Fighter radio signal coverage and "dead spots"**
- **Emergency responders lose communications**

The Coverage Problem





SPRINKLER POINT LEGEND			
ADDRESS	POINT	ADDRESS	POINT
97-M.1	WATER FLOW	97-M.17	WATER FLOW
97-M.2	TAMPER VALVE	97-M.18	TAMPER VALVE
97-M.3	TAMPER VALVE	97-M.19	WATER FLOW
97-M.4	TAMPER VALVE	97-M.20	TAMPER VALVE
97-M.5	TAMPER VALVE	97-M.21	WATER FLOW
97-M.6	TAMPER VALVE	97-M.22	TAMPER VALVE
97-M.7	TAMPER VALVE	97-M.23	WATER FLOW
97-M.8	TAMPER VALVE	97-M.24	TAMPER VALVE
97-M.9	WATER FLOW	97-M.25	WATER FLOW
97-M.10	TAMPER VALVE	97-M.26	TAMPER VALVE
97-M.11	PUMP RUN	97-M.27	WATER FLOW
97-M.12	ACTIOWER FXCL	97-M.28	TAMPER VALVE
97-M.13	PHASE REVERSAL	97-M.34	WATER FLOW
97-M.15	WATER FLOW	97-M.35	TAMPER VALVE
97-M.16	TAMPER VALVE		



DB MEASURE:
ROOF
4 EXTERIOR CORNERS AT GROUND EXTERIOR
EACH APARTMENT
5 SPOTS DOWN EACH HALLWAY
BASEMENT AND FIRST FLOOR ROOMS
PARKING GARAGE A COUPLE SPOTS.

Fire Alarm Symbol Legend

SYMBOL	DESCRIPTION
	INTELLIGENT, FACP (SCIB, 9 SD FLEXPUT CIRCUITS
	INTELLIGENT 10" TOUCH ANNUNCIATOR
	REMOTE PAGING UNIT, SUPERVISED
	REMOTE LCD ANNUNCIATOR, 80C
	INTELLIGENT, FI, 1 SD FLEXPUT CIRCUITS
	L-SERIES SPEAKER, WHITE, CEILING
	SPEAKER, WHITE, WALL
	L-SERIES SPEAKER/STROBE, WHITE, CEILING
	L-SERIES SPEAKER/STROBE, WHITE, WALL
	WALL SPEAKER STROBE WHITE OUTDOOR
	L-SERIES STROBE, WHITE, WALL
	L-SERIES STROBE, 2 WIRE, W-C, WHITE, CEILING
	EOL 4.7K
	EOL 15K
	PULL STATION, DOUBLE ACTION, ADDRESSABLE
	INTERFACE MODULE, ADDRESSABLE
	RELAY MODULE, ADDRESSABLE
	SMOKE, PHOTOELECTRIC, ADDRESSABLE
	HEAT, RATE OF RISE, ADDRESSABLE
	ISOLATOR MODULE
	WATER FLOW
	TAMPER ALARM
	ANS FIRE ALARM RADIO

THE GRAINARY APARTMENTS
LOWER LEVEL / PARKING GARAGE FA LAYOUT

SCALE: 1/8" = 1'-0"
AREA: 10,909 SQ FT

Best Defense
Fire Protection & Security, Inc.

Best Defense
300 Morrivan Valley Rd.
Waunakee, WI 53597

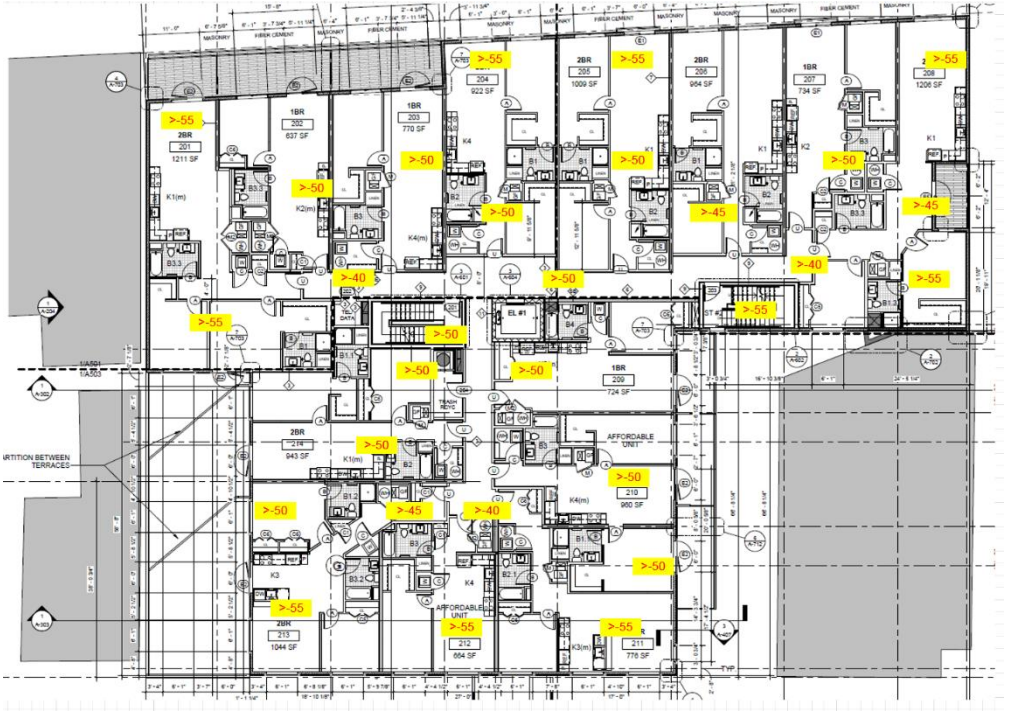
The Grainary Apartments
720 West Virginia Street
Milwaukee, WI 53204

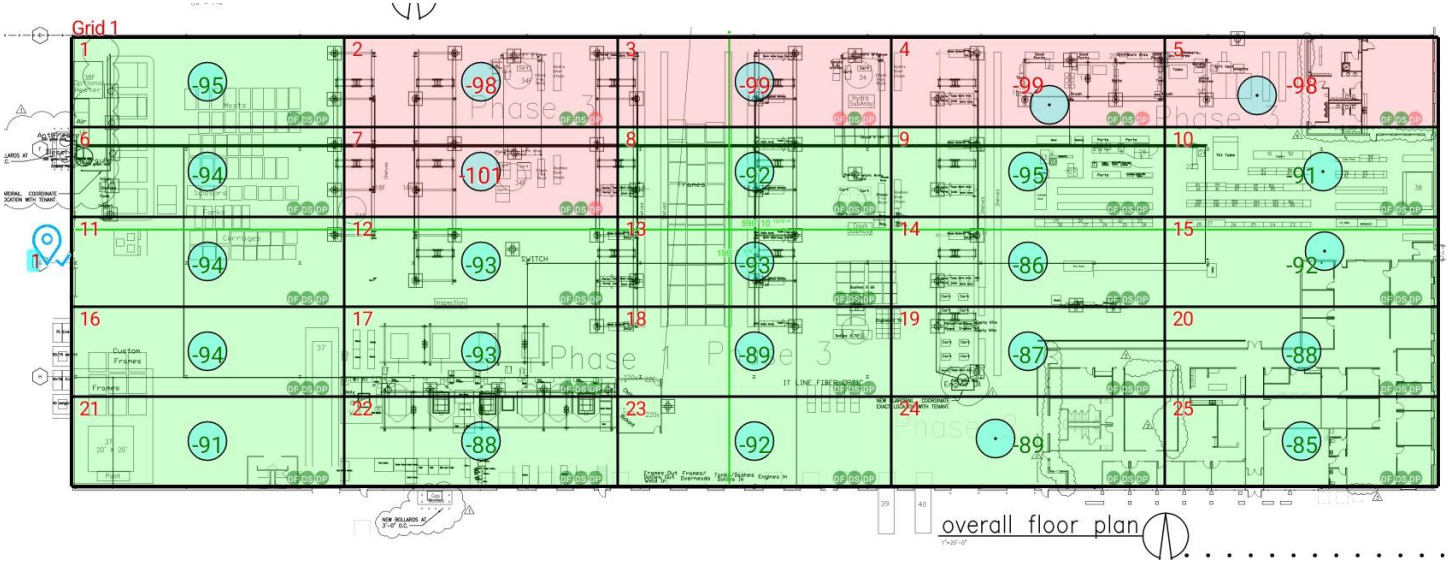
FIRE ALARM SYSTEM

REV. #	DATE	DESCRIPTION
REV. A	11/21/18	REVISION CLOUDED ON PLANS

Sheet: FA.01
(03 OF 14)

Radio Signal Survey – The “Coverage Map”

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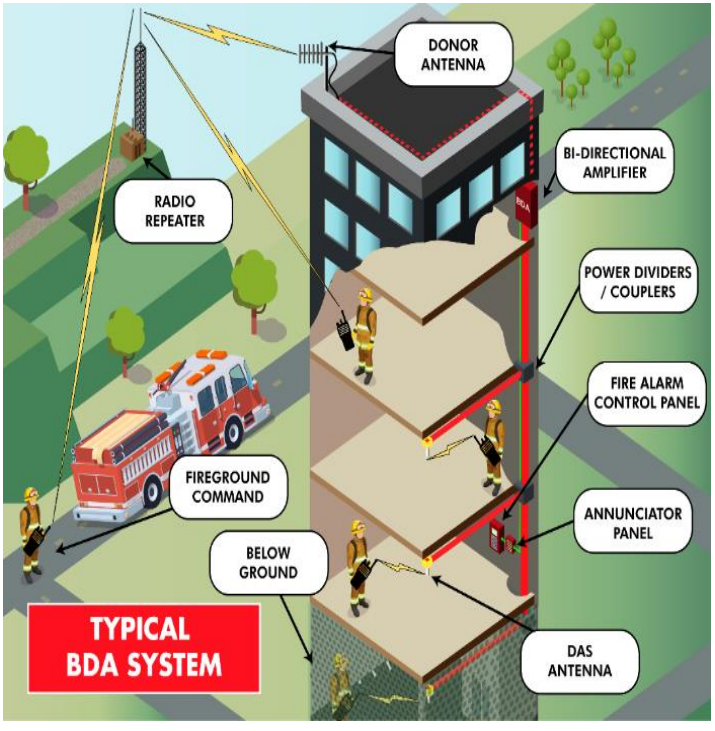
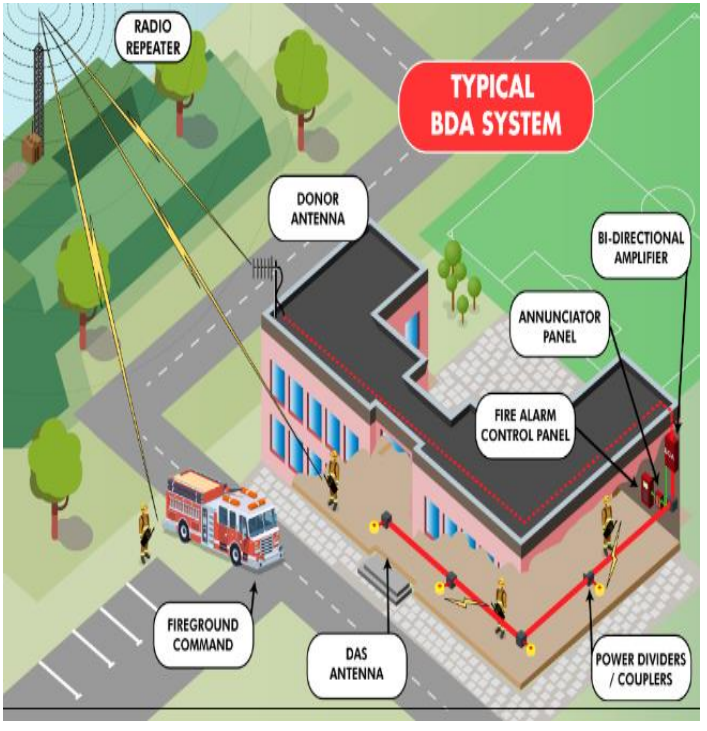
overall floor plan

ERRCES / BDA - The Coverage SOLUTION:





BDA System Components

Donor Antenna

- Installed on the Roof of the building
- Pointing to the public safety radio repeater site
- High gain, high directivity
- Does not need line of sight

Coaxial Cable

- Typically Plenum Rated, ½" diameter
- Low insertion loss is required
- Red cable
- Some AHJs have special labeling requirements

Honeywell Passive DAS Devices

- **Cable from RFS**
- **Complete line of passive components** for Public Safety IBW systems.
- Full 136 – 870MHz frequency range for Public Safety
- **Power Splitters:** 2, 3 and 4 ways (**DPS Series**)
- **RF Couplers:** 6, 8, 10, 15, 20 & 30dB (**DC Series**)
- **3dB hybrid coupler** (**HC Series**)
- **Dual band combiner:** 136-174MHz & 380-520MHz (**DBC Series**)
- **Dual band combiner:** 136-520MHz & 698-2700MHz (**DBC Series**)
- **Triple band combiner:** 136-174MHz & 380-520MHz & 758-869MHz (**MBC Series**)
- **Attenuators** (**AT Series**)
- **50ohms Loads** (**LD Series**)
- **Isolators** (**LTB Series**)
- **N(f) connectors as standard**
- **BTS Duplexers, Filters, TX Combiners, RX Multi-couplers and more…**

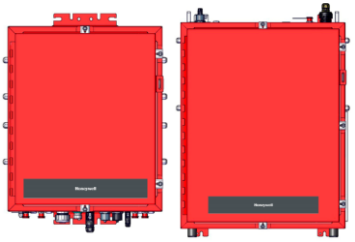
1176

HONEYWELL BDA PORTFOLIO

DH7S

700/800 + FirstNet

BDA
Fiber DAS Master
Fiber DAS Remote



DH14

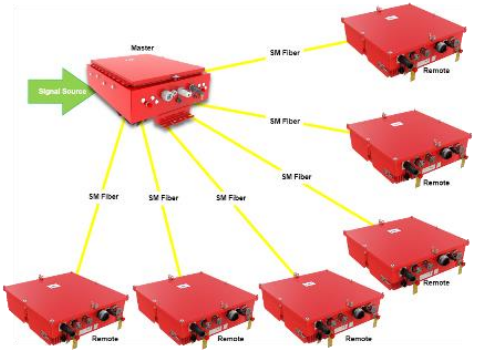
VHF/UHF

BDA
Fiber DAS Master
Fiber DAS Remote

Rack Chassis

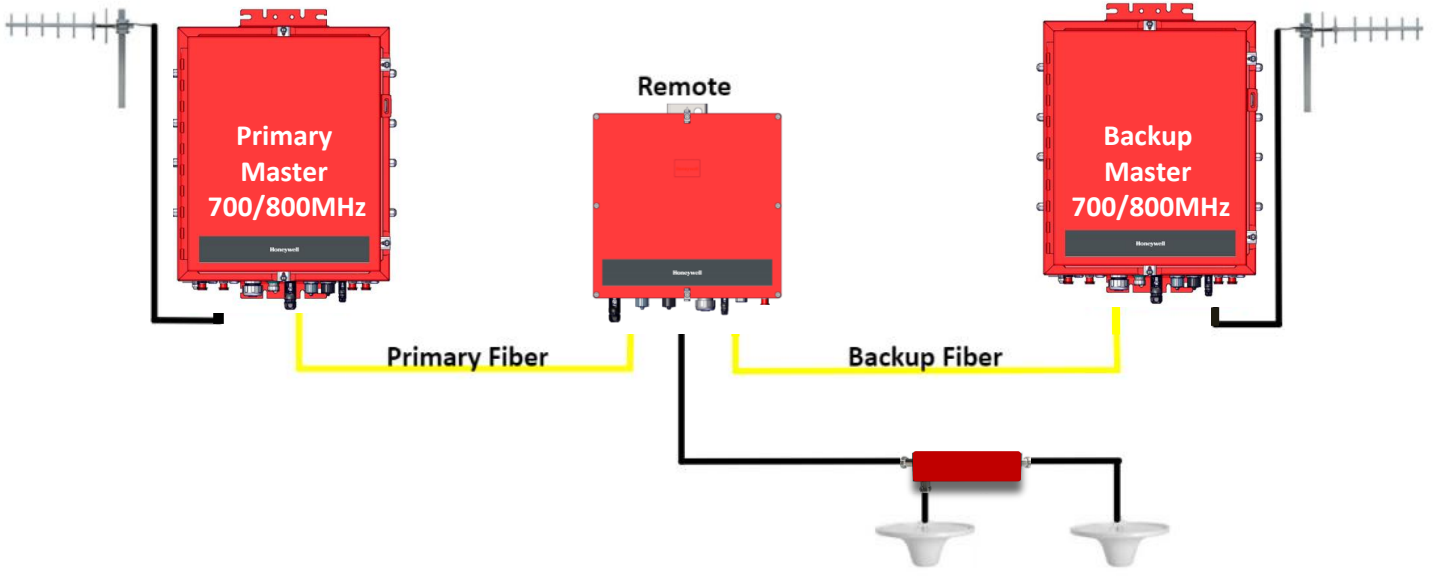
700/800 + FirstNet

Fiber DAS Master



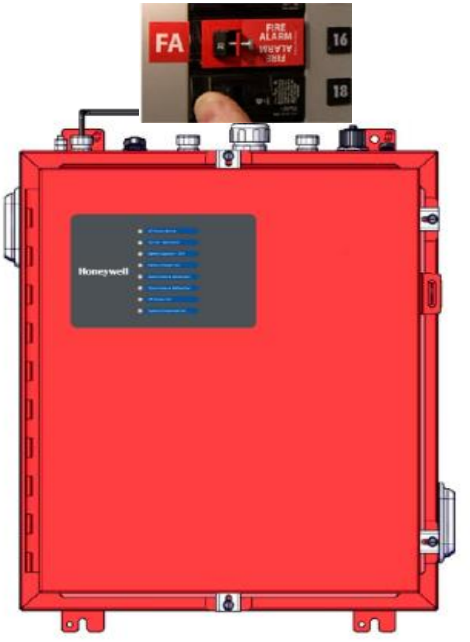
Four Flexible Chassis Formats …

HONEYWELL FIBER DAS REDUNDANCY



HONEYWELL MASTER REDUNDANCY

Honeywell
Battery
Backup
Units & annunciators



Honeywell Battery backup Specifications

Model:

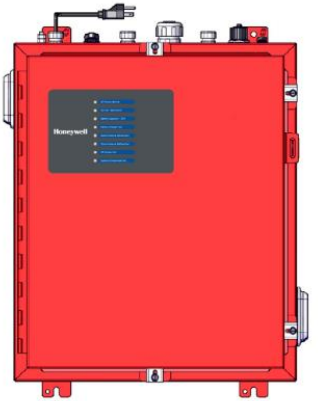
BTTY-100055 (12hrs)

BTTY-100100 (24hrs)

BTTY-ANN xxx (Remote Annunciator)

Standard Features:

- UL2524 2nd Edition Listing
- Batteries included - **Capacity: 55Ah or 100Ah**
- 55Ah provides 12 hours backup time for 100W BDA
- 100Ah provides 24hrs/100W BDA OR 12hrs/200W BDA
- MAX load 270W
- NFPA 72 compliant
- Built-in annunciator
- Up to 4 remote annunciators can be connected in parallel
- 120VAC input / +24VDC output
- IP67 / NEMA4 enclosure
- Tamper proof with lock and key accessibility
- Graphical user interface for easy setup
- Dimensions: 24 x 20 x 10 in.
- Weight – 55Ah: 150 lbs.; 100Ah = 210 lbs.

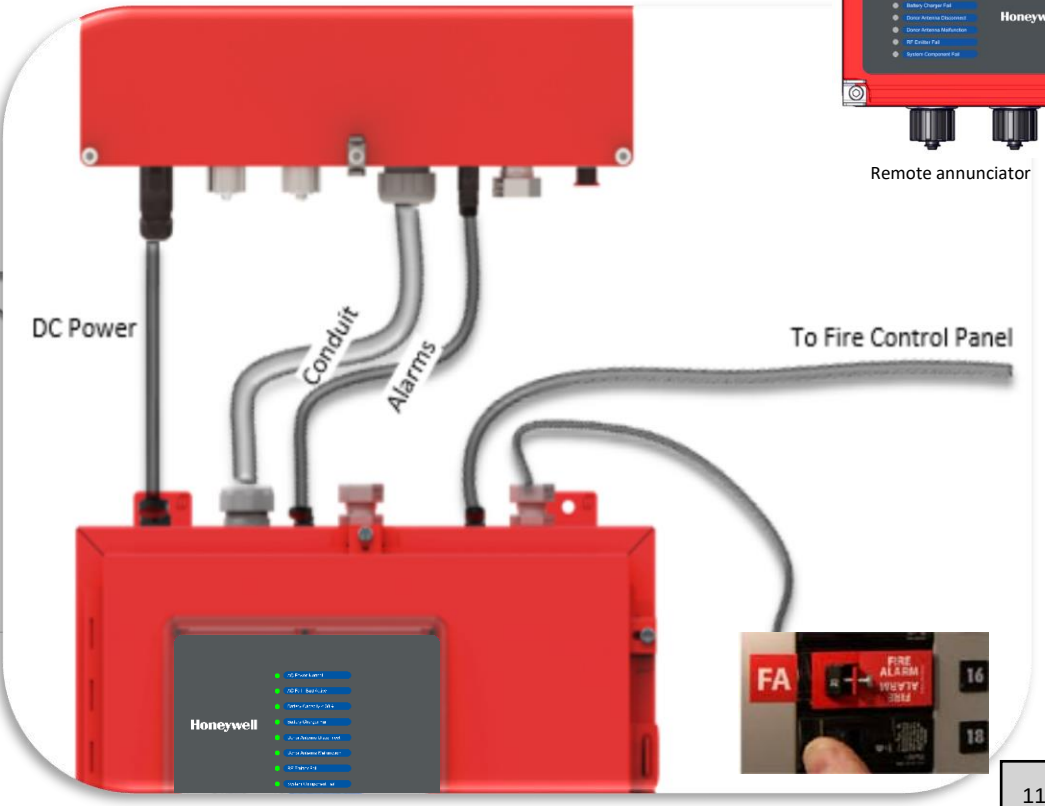


BTTY-100055 (12hrs)
BTTY-100100 (24hrs)

BTTY-ANN 003 (with contacts)
BTTY-ANN 004

1180

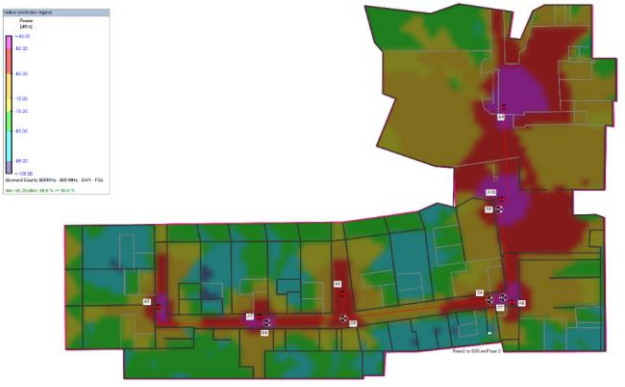
Honeywell BDA/DAS - BBU System

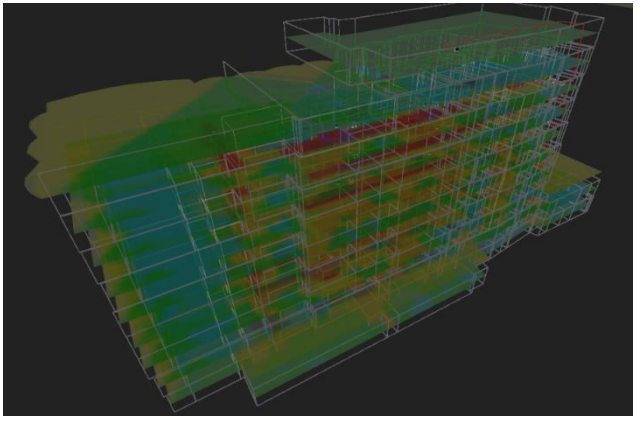


Remote annunciator

IB-Wave Design

- Benefits of IB-Wave Modeling
  - Signal Prediction for new construction.
  - Design layout for installers.
  - Submittal documentation for AHJ's and A&E's.





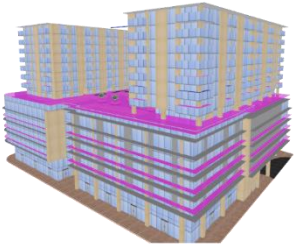
1182

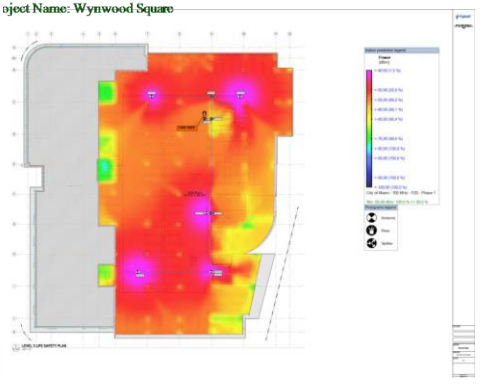
IBWAVE Design and support of AHJ package

Equipment List Report

Project name:	Wynwood Square	**Design company:**	Fiplex Communications Inc
Project creation date:	25/04/2019	**Designer:**	Gonzalo Ponce de Leon

Type	Manufacturer	Model	Description	Inventory#	Qty
Antenna	Galtronics	PEAR S5379	Small Size In-Building True Omni Ceiling Mount Antenna, 698-6000 MHz, 1x N-	N/A	64
Antenna	Galtronics	PEAR S5591i	Directional Outdoor/In-Building Antenna [TETRA + Cellular], V-Pol: 380-2700 MHz, 1x N-Female with Cable	N/A	6
Antenna	G-Wave	TDJ-700/2500YG	Yagi Antenna - 7.5/8.5/10 dBi outdoor triple band, 698-800 / 800-960 MHz / 1700-2700 MHz - N Connectors	N/A	1
Attenuator	PolyPhaser	GT-NFF-AL	Lightning Arrester - DC Pass	N/A	1
BDA	Fiplex	DH7S-002-10	DIGITAL SIGNAL BOOSTER. PS 800 + 700 MHz + FirstNet, Dual Band +33dBm, Class B, 2 Adj sub band, DC, NFPA	N/A	1
Cable	RFS	ICA12-50JPL-A11	Plenum Rated Low-Loss Coaxial Cable 1/2"	N/A	5018,53 feet
Cable	RFS	NMNMI12P-060FFP	Jumper Cable - 6 feet - ICA12-50JPL - N Male / N Male - In-Building	N/A	24
Connector	RFS	NM-LCF12-D01	N Male OMNI FIT Connector for LCF12-50 Cable	N/A	234
Miscellaneous	Fiplex	BTTY-001	Battery Backup Unit Controller, 24 VDC, 10A, NFPA / UL-2524	N/A	1
Miscellaneous	Fiplex	BTTY-BATT PACK	Battery Box for BTTY-00x. NFPA / UL-2524, NEMA 3R	N/A	
Miscellaneous	Fiplex	BTTY-ANN	5-alarm NFPA annunciator, single and dual band options. NFPA / UL-2524	N/A	
Splitter	Microlab/FXR	CK-15N	Ultra Wide Band Stripline Coupler, PIM <- 155 dBc, 15 dB, 698-3600 MHz, N Type Connectors <Last Modified: 20-11-14>	N/A	4
Splitter	Microlab/FXR	CK-16N	Ultra Wide Band Stripline Coupler, PIM <- 155 dBc, 6 dB, 698-3600 MHz, Type N Connectors <Last Modified: 20-11-14>	N/A	61
Splitter	Microlab/FXR	CK-17N	Ultra Wide Band Stripline Coupler, PIM <- 155 dBc, 10 dB, 698-3600 MHz, N-type connectors <Last Modified: 20-11-14>	N/A	4

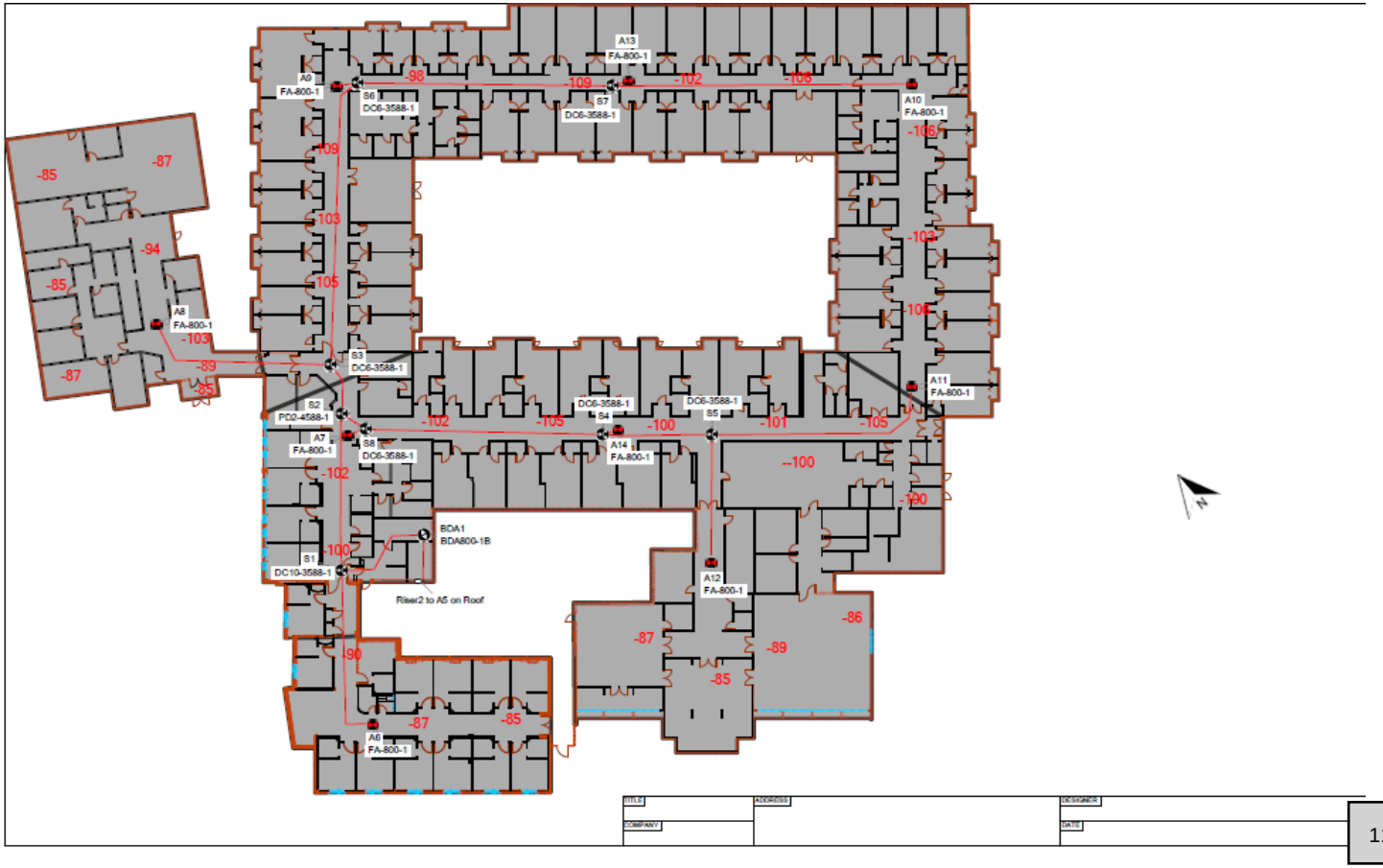


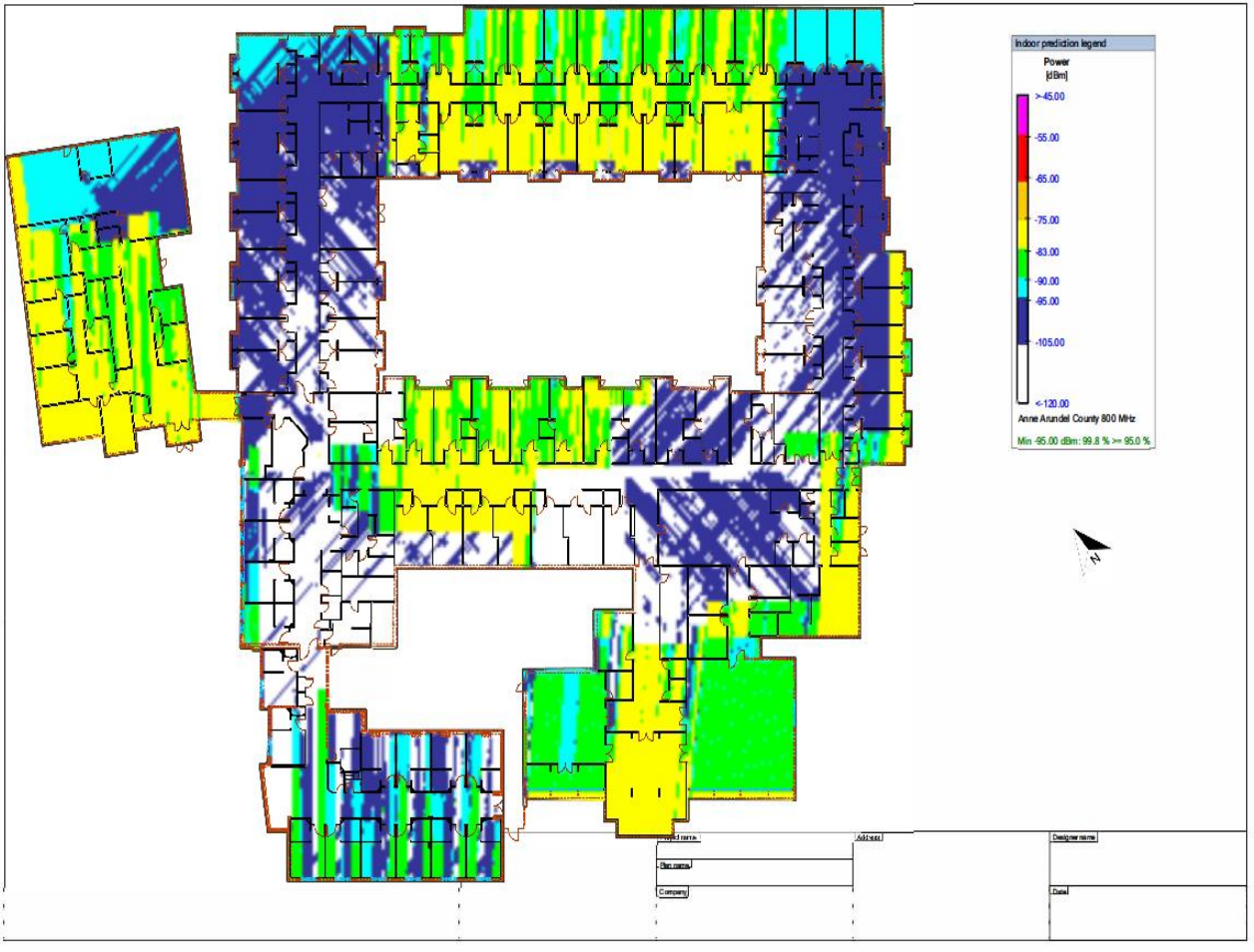


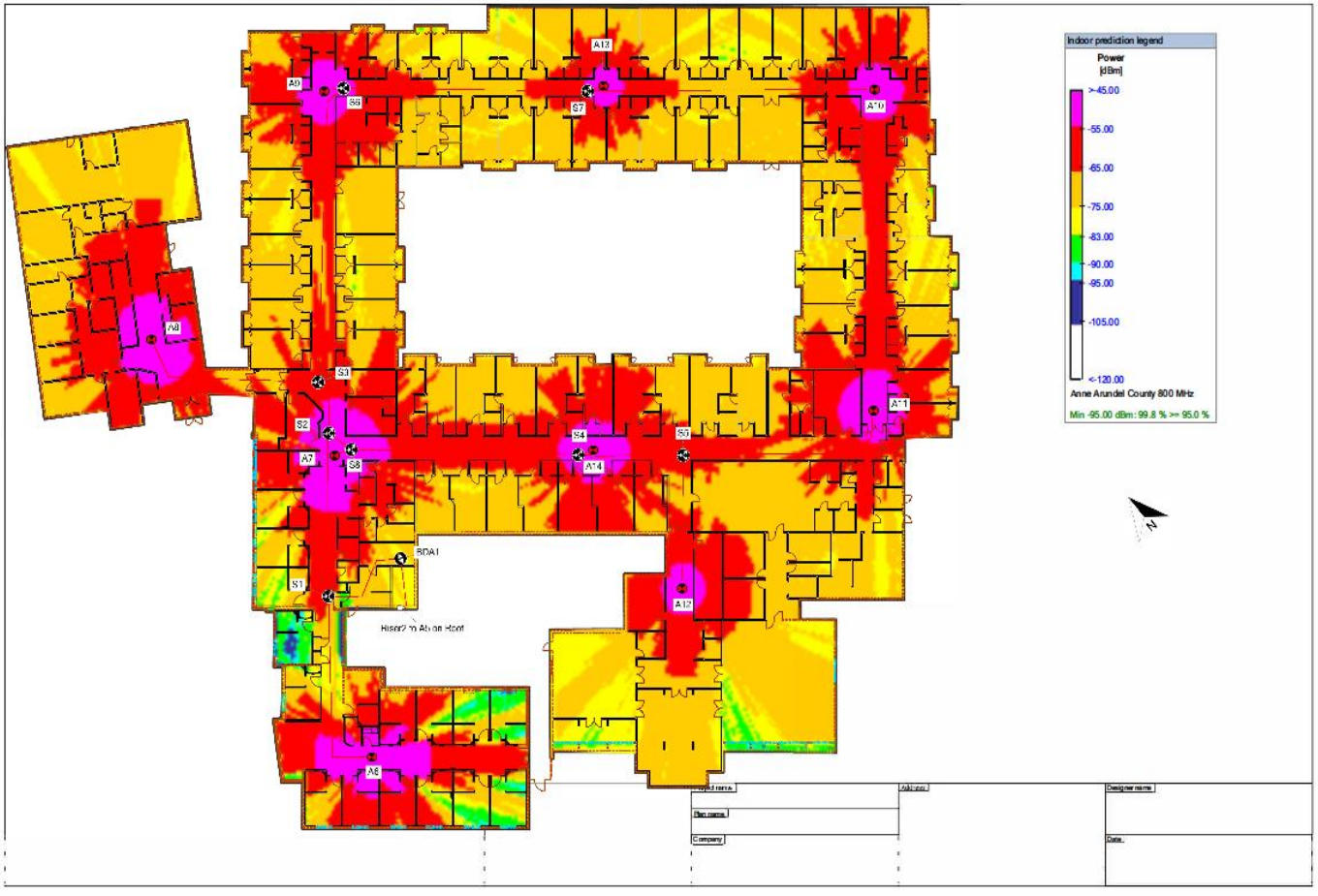
COMPLETE TURNKEY OFFERING – DESIGN TO EQUIPMENT

1183

Typical Signal Survey Report




Indoor prediction legend
Power
[dBm]
>-45.00
-55.00
-65.00
-75.00
-83.00
-90.00
-95.00
-105.00
<-120.00
Anne Arundel County 800 MHz
Min -95.00 dBm: 99.8 % >= 95.0 %
N
Project name
Add copy
Designer name
Plan name
Company
Date


Indoor prediction legend
Power
[dBm]
>-45.00
-55.00
-65.00
-75.00
-83.00
-90.00
-95.00
-105.00
<-120.00
Anne Arundel County 800 MHz
Min -95.00 dBm: 99.8 % >= 95.0 %
BDA1
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
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S1
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N

Going Into the UNKNOWN:
Will My Radio Work In This Building?

Radio Signal Survey

Determines if a building has sufficient radio signal coverage or if it needs a signal enhancement (ERRCES) system.

It is a responsibility of the building owner or construction company to perform survey and to certify signal coverage on a 100% completed building. Survey report needs to be submitted to the AHJ.

AHJ Should have signal surveys for all buildings in the jurisdiction.

Signal enhancement (ERRCES) is required for building with insufficient coverage.

Final survey / signal coverage certification is done upon building completion.

Surveys are done by FCC GROL certified technicians. Minimum 20 readings per floor. Test all critical areas. Report submitted to AHJ.

AHJ CONCERNS ABOUT ERCES

Polling Question

Which of these is your biggest concern about ERCES?

1.) Impact of Improper Installation
2.) Noise Floor Concerns
3.) Component Failure
4.) Competency of Designer & Installer
) 5.) Oscillation

Concerns About ERCES Systems

Improper installation or a failure could lead to **oscillation** (donor antenna signal feeds back into the DAS), creating harmful interference to Public Safety Radio System.

Noise on uplink can potentially add up & cause signal degradation for firefighter radio systems.

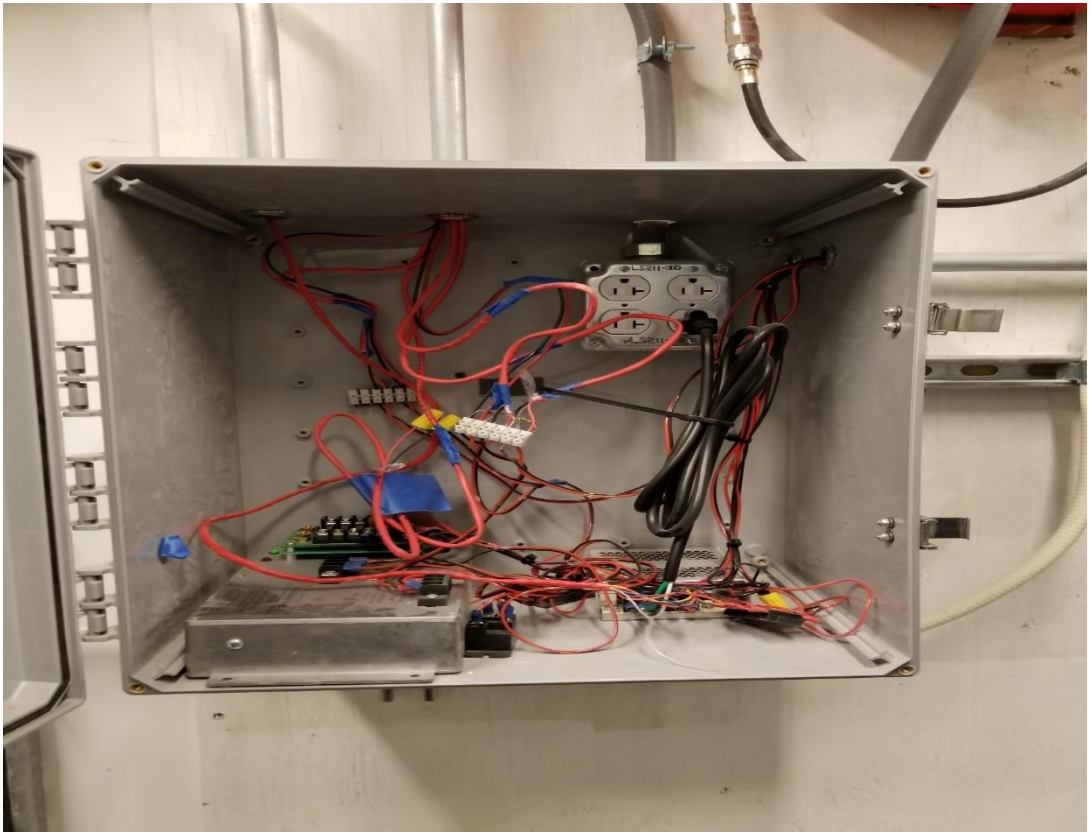
Failure of A System Component may go unnoticed without proper monitoring & supervision (required by NFPA 1221), resulting in the system NOT being available when you need it most.

"Competency" of System Designer & Installer

How do AHJs **specify & ensure compliance**?

Should ERRCES products be regulated. Is this what you want installed!!!!!!

1193



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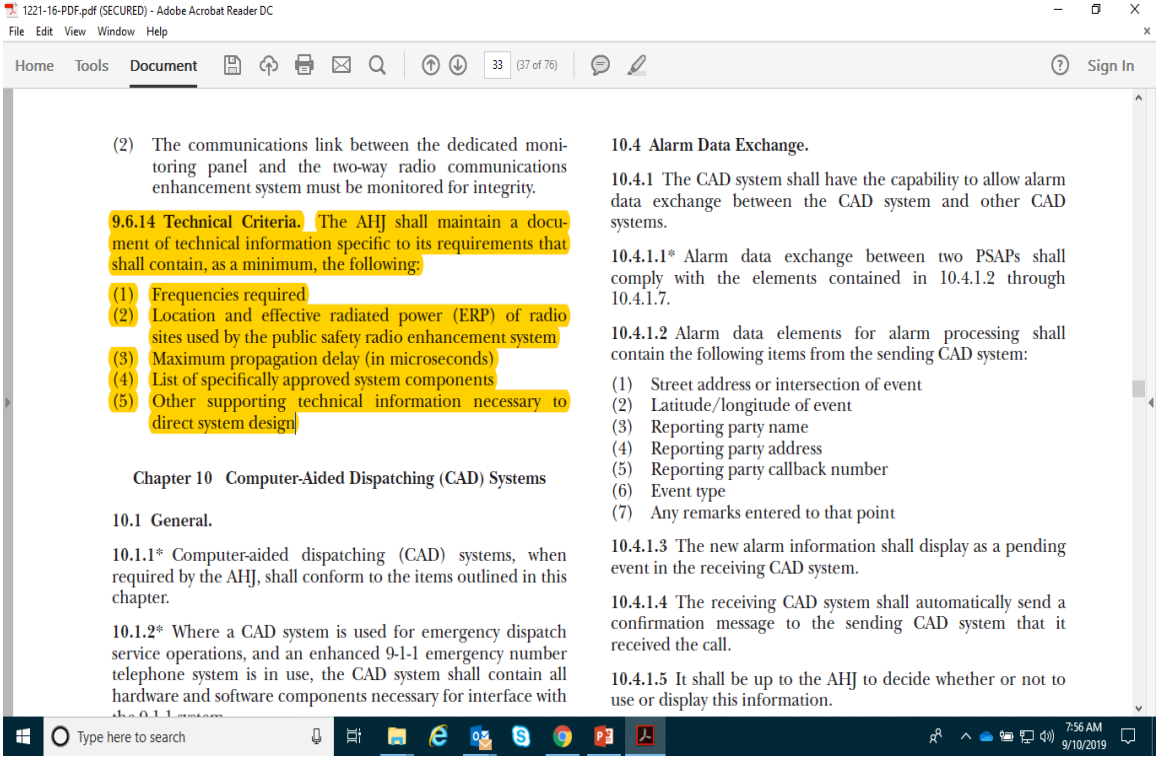
How do AHJs specify & ensure compliance

1196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33 (37 of 76)
Sign In
(2) The communications link between the dedicated monitoring panel and the two-way radio communications enhancement system must be monitored for integrity.
9.6.14 Technical Criteria. The AHJ shall maintain a document of technical information specific to its requirements that shall contain, as a minimum, the following:
(1) Frequencies required
(2) Location and effective radiated power (ERP) of radio sites used by the public safety radio enhancement system
(3) Maximum propagation delay (in microseconds)
(4) List of specifically approved system components
(5) Other supporting technical information necessary to direct system design
Chapter 10 Computer-Aided Dispatching (CAD) Systems
10.1 General.
10.1.1* Computer-aided dispatching (CAD) systems, when required by the AHJ, shall conform to the items outlined in this chapter.
10.1.2* Where a CAD system is used for emergency dispatch service operations, and an enhanced 9-1-1 emergency number telephone system is in use, the CAD system shall contain all hardware and software components necessary for interface with
10.4 Alarm Data Exchange.
10.4.1 The CAD system shall have the capability to allow alarm data exchange between the CAD system and other CAD systems.
10.4.1.1* Alarm data exchange between two PSAPs shall comply with the elements contained in 10.4.1.2 through 10.4.1.7.
10.4.1.2 Alarm data elements for alarm processing shall contain the following items from the sending CAD system:
(1) Street address or intersection of event
(2) Latitude/longitude of event
(3) Reporting party name
(4) Reporting party address
(5) Reporting party callback number
(6) Event type
(7) Any remarks entered to that point
10.4.1.3 The new alarm information shall display as a pending event in the receiving CAD system.
10.4.1.4 The receiving CAD system shall automatically send a confirmation message to the sending CAD system that it received the call.
10.4.1.5 It shall be up to the AHJ to decide whether or not to use or display this information.
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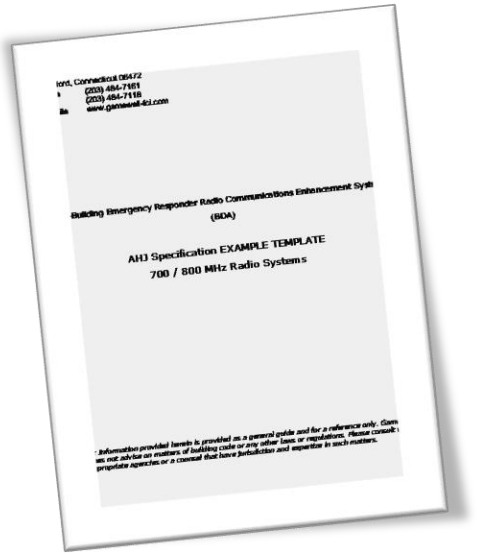
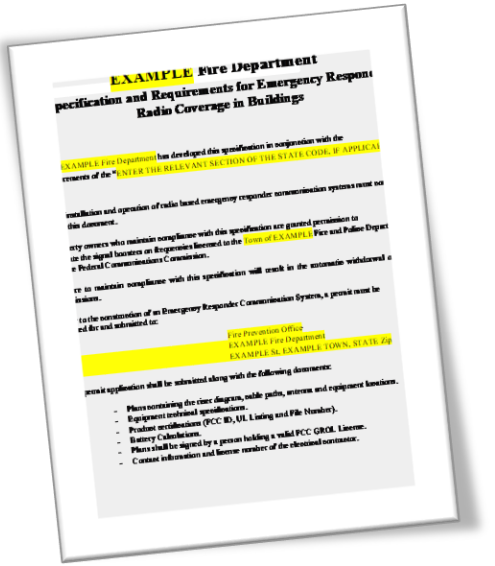
9/10/2019

AHJ ERCES SPECIFICATION DEVELOPMENT





Koorsen can help you develop your specifications!

Editable AE and AHJ Specifications and Sample AHJ Specifications from around the US

Koorsen FIRE & SECURITY

Elements of the AHJ ERCES Specification

Technical
Frequency Coverage
Radio Site Locations
Permitting Process
Testing & Acceptance
UL Listing, Regulatory Requirements
It's a Performance-Based Specification, "no need to over-specify"

Administrative
AHJ Contact Information
Permitting & Certification Forms
Submittal Documentation Requirements
Maintenance Contract Requirements & Certifications
Applicable Code References
Installer Qualification Requirements

FCC Certification and Registration Requirements

Signal Boosters must be FCC certified (manufacturer product brochures and product labels must include FCC ID number)

BDAs are FCC certified to operate on the licensee's frequencies

FCC Requires frequency licensees (FD, PD, municipality, etc.) to register all signal boosters that operate on their frequencies

Registration is free and FCC has a simple on-line registration tool:
https://signalboosters.fcc.gov/signal-boosters

Registration should be done by the AHJ (frequency licensee) because it requires the licensee FRN (federal registration) number and FCC password.

BDA vendor can assist if needed

Signal Booster
Class A vs Class B?

Signal Boosters – Class A or Class B?
What is the difference? Which one is better?

FCC classifies signal boosters as either Class A or Class B.

FCC Definitions per 47CFR90.219 rule:

Class A signal booster: "A signal booster designed to retransmit signals on one or more specific channels. A signal booster is deemed to be a Class A signal booster if none of its passbands exceed 75 kHz."

Class B signal booster: "A signal booster designed to retransmit any signals within a wide frequency band. A signal booster is deemed to be a Class B signal booster if it has a passband that exceeds 75 kHz."

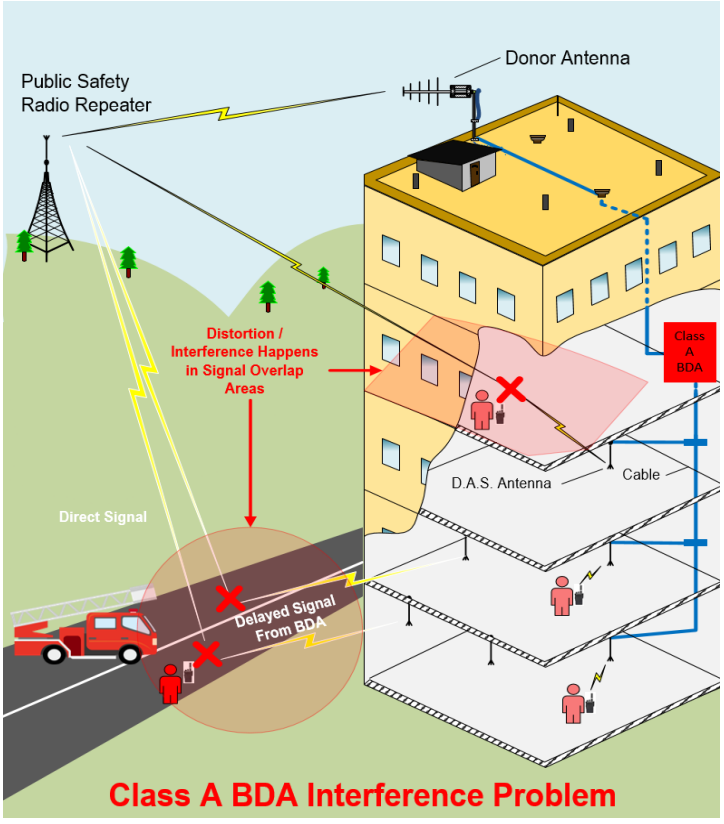
Note: This classification is different from Class A and Class B fire alarm circuit wiring.

Signal Boosters – Class A vs Class B

Class A	Class B
Maximum Passband is 75KHz. Intended to amplify no more than one channel at one time	Maximum Passband is more than 75KHz. It can amplify more than one channel at the same time It can either be broadband or band-selective.
Mobile use allowed	Fixed use only
Introduces signal delay (aka “group delay”) of over 50 microseconds resulting in signal distortion and interference in signal overlap areas	Very low to negligible signal delay (usually less than 2 us). Does not introduce signal distortion and interference in signal overlap areas.
Higher power consumption, higher heat dissipation = lower efficiency	Lower power consumption, less heat dissipation = higher efficiency

Myth # 4: Class A signal boosters do not create interference

Fact: Probably the least understood, yet the biggest shortcoming of class A signal boosters is the fact that they distort the radio signal by delaying it by more than 50 microseconds, which degrades the signal in the overlap areas and creates harmful interference.



Fire Marshall
Architect and Engineer Considerations

Did You Know?

Many design professionals are not aware of the requirements for Emergency Responder Radio Coverage even if required by code

If ERRS Levels are not referenced on a building submittal or construction documents, the fire official should immediately notify the building official and design professional that the signals levels must be evaluated; and if the existing radio coverage has not been met, then ERRCES must be provided.

2016 NFPA 1221 BDA Pathway Survivability Requirements

9.6.2.1.1* Where a two-way radio communications enhancement system is used in lieu of a two-way in building wired emergency communications system, it shall have a pathway survivability of Level 1, Level 2, or Level 3.

9.6.2.1.1.1 The feeder and riser coaxial cables shall be rated as plenum cables that match the building's fire rating and pathway survivability.

9.6.2.1.3* Riser coaxial cables shall be rated as riser cables and routed through a 2-hour–rated enclosure.

9.6.2.1.4 The connection between the riser and feeder coaxial cables shall be made within an enclosure matching the building's fire rating and pathway survivability, and passage of the feeder cable in and out of the enclosure shall be fire-stopped to the building's fire rating and pathway survivability.

9.6.3* Systems shall have lightning protection that complies with NFPA 780.

2019 NFPA 1221 BDA Pathway Survivability Requirements

The Backbone (Riser) Cable shall have a pathway survivability of Level 1, Level 2, or Level 3 to match the buildings rating.

The feeder and riser coaxial cables shall be rated as plenum cables that match the building's fire rating and pathway survivability.

The connection between the riser and feeder coaxial cables shall be made within an enclosure matching the building's fire rating and pathway survivability, and passage of the feeder cable in and out of the enclosure shall be fire-stopped to the building's fire rating and pathway survivability.

Systems shall have lightning protection that complies with NFPA 780.

SUMMARY

SITUATION

Emergency Responders -Firefighters, EMS and Law Enforcement Officers rely on two-way radios for communications in every day operations

PROBLEM

Radio signals in-building are weakened by structures such as concrete, windows, metal, underground, etc., Emergency responders lack in-building radio coverage

SOLUTION

Enhance in-building radio frequency signal coverage with Honeywell's UL 2524 listed Bi-Directional Amplifier (signal booster) and Distributed Antenna System

Koorsen FIRE & SECURITY

Additional Resources

https://www.saferbuildings.org

QUESTIONS & ANSWERS?

Thank You for Your Time

David Thompson
david.thompson@koorsen.com

File Attachments for Item:

EC-14 BlazeMaster Fire Protection Installation Training (Lubrizol Advanced Materials)

All certifications (2 hours)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Julie E. Schade

Organization: Blaze Master CPVC Fire Protection Systems (Lubrizol Advanced Materials)

Address: 9911 Brecksville Rd. Brecksville, OH 44141

E-mail: julie.schade@lubrizol.com Telephone: 216-447-5677

Website: www.blazemaster.com

Conference Sponsor (if applicable) — Conference Email: —

Check here if Course Renewal: — Prior course number — *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Blazemaster Fire Protection Installation Training

Course instructor: multiple

Course description: Review of proper installation for Blazemaster CPVC Fire Protection Systems, chemical compatibility, best practices, cut & join process

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: online anytime, as requested by company

Special Content:

Code Administration: X

Existing Buildings: X

Electrical Instruction: _____

Plumbing Instruction: _____

Conference Course: _____

Conference Name: _____

Conference location: _____

Course to be offered online? X **On Demand** X **Webinar** _____

Course Website: www.blazemastertraining.com

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
test, videos, cut & join demonstration

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

X Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

BlazeMaster Installation Training Agenda

Course Description and Content:

• Know the Listings and Approvals necessary for installation of CPVC fire sprinkler systems	15 min.
• Understand the advantages of a CPVC fire sprinkler system	15 min.
• Understand the various design parameters for CPVC fire sprinkler systems and where CPVC is allowed to be installed	30 min.
• Understand the correct joining method of CPVC pipe and fittings	30 min.
• Understand the difference between concealed and exposed systems	15 min.
• Understand the various options for freeze protection	15 min.
• Understand chemical compatibility and the potential issues when using incompatible ancillary products	15 min.
• Understand support and hanging requirements of CPVC	15 min.

OHIO CEU Presenters Biographies –

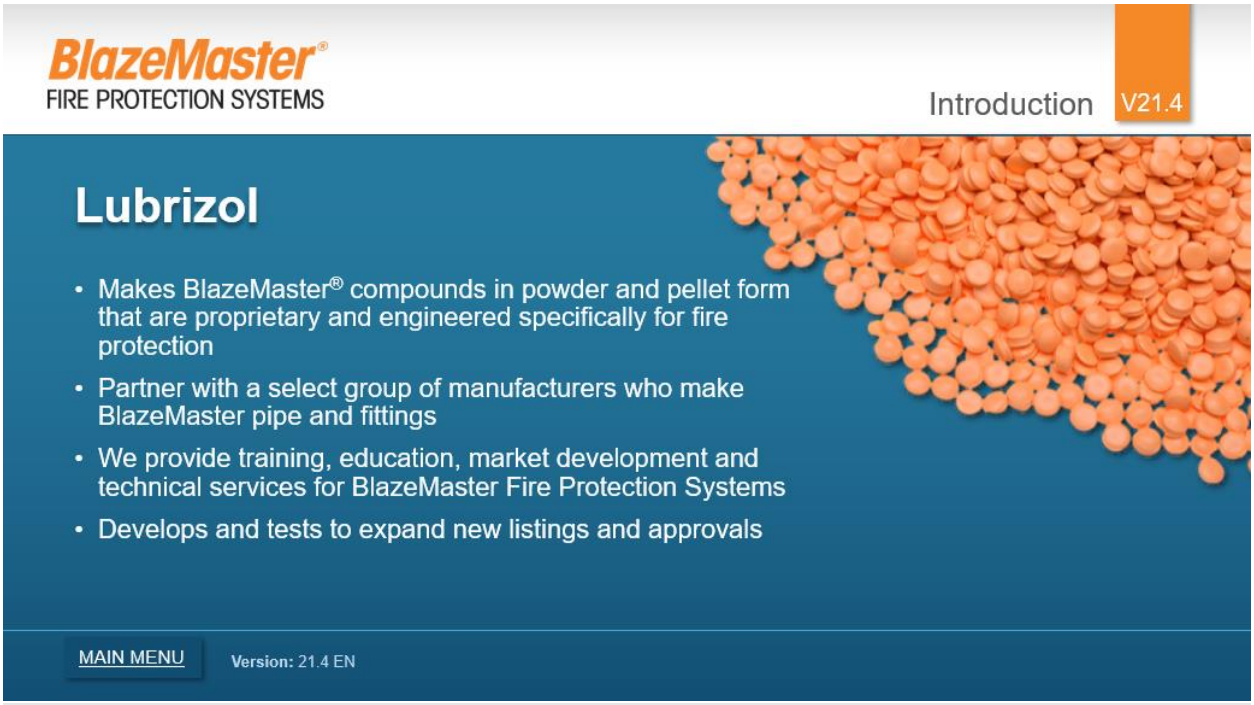
Joshua Horan
Joshua has enjoyed supporting the Thermoplastics industry for more than 15 years. His role with Lubrizol touches all aspects of the construction lifecycle, from specification to installation guidance for the brands FlowGuard Gold, Corzan, and BlazeMaster. He maintains a close connection with the engineering community through educational presentations, and the trades through on-site training and involvement with local trade schools as a guest instructor.

Lainey Liotta
Lainey is the Fire Protection Market Manager for LZAM's TempRite® business and is primarily responsible for setting the business strategy for BlazeMaster® Fire Sprinkler Systems and UL listed freezemaster™ antifreeze. A Penn State graduate with two degrees in Marketing and Spanish, Lainey started out her professional career at Tyco (now Johnson Controls.) Throughout her five years there, she held various product manager and commercial roles in their fire suppression business. After, she worked in business development for Chemours, focusing on driving forward the safe adoption of HFO refrigerants. She then joined Lubrizol in 2019, excited to get back into the fire protection industry. Lainey is a member of various NFSA, AFSA, and IFSA committees and is passionate about her role in advancing fire safety in buildings around the world.

Peter Mullen
Peter has more than 30 years of experience in sales, marketing and new business development in the plastic piping industry, with the last 25 specializing in CPVC with Lubrizol Advanced Materials (formerly Noveon and B.F. Goodrich). His experience covers plumbing, industrial, and fire protection applications, with additional experience in CPVC building products. Markets served include the residential and commercial plumbing & fire protection, chemical process, wastewater treatment, semiconductor, aerospace and metal treatment and refining. Global new business development assignments have also been completed while working with Lubrizol. Previous experience includes sales of other thermoplastic piping materials, including vinyl, polyolefins and fluoropolymers.

John Pritchard
John has been a piping systems consultant with Lubrizol for the past 12 years. John is a Chicago Licensed plumber and a member of Plumbers local # 130 over 35 years' experience in the plumbing/Mechanical Piping Industry. Bachelor of Science degree in Construction Management from Western Illinois University (1983). Member of the Western Illinois University Engineering Technology Advisory Council. Has worked as an instructor for the Residential Construction Employers Council (RCEC) Construction Management Certification Program (CMCP).

BlazeMaster V21.4 Print Screens for Ohio CEU – 2023



Talk Points:

- Lubrizol produces CPVC powder (for pipe) and pellets (for fittings).
- Licensed manufacturers make the pipe and fittings.
- *These select partners are strategic, long-term, and provide the highest level of quality and service.*
- These manufacturers have their own installation instructions.
- Not all orange pipe is BlazeMaster and not all CPVC is the same.
- BlazeMaster CPVC is a proprietary compound engineered specifically for fire protection yielding superior material properties and performance

Importance of Installation Training

- Creates common approach to installation best practices
- Educates the market on codes, chemical compatibility and installation
- Demonstrates a sense of quality, care and concern for the life safety systems being installed through the issuance of an installation training card

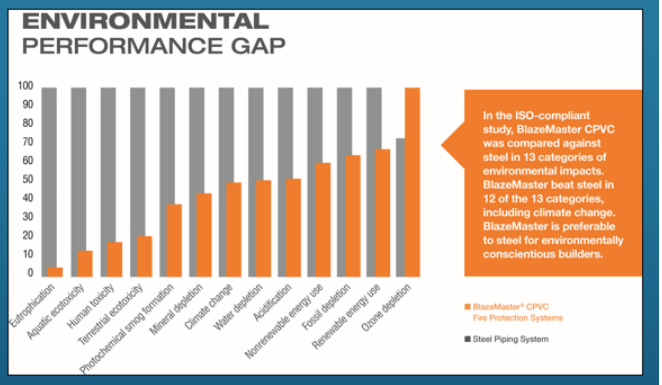
BlazeMaster Advantages

- Proven performance since 1984
- Specially listed for fire protection. BlazeMaster Manufacturers' Installation Guides are part of their UL / ULC listing and should be followed
- BlazeMaster pipe and fittings will not corrode or scale
- Pipe is designed for a 50-year service life with a safety factor of 2
- Clean & light-weight
- Hazen-Williams C-Factor = increased hydraulic capabilities allow for pipe downsizing
  - BlazeMaster has less friction loss than steel
  - BlazeMaster = 150 (will not decline over time) vs. "new" steel = 120 (steel will decline over time)

Talk Points:
-BlazeMaster systems carry a variety of advantages over metal systems.
-BlazeMaster is lightweight and since most of the sprinkler work is overhead, using BlazeMaster results in less wear and tear on the installers.
-No need for shop fabrication so the material is on the jobsite weeks sooner.
-Can start and stop anywhere – steel can't do this.
-Can possibly be attached directly to the wall or ceiling. This is a huge advantage that steel does not have and is possibly the #1 reason we are in high-rise.
-BlazeMaster has less friction loss than steel: Steel is 120 BlazeMaster is 150
- **Therefore, you can downsize the pipe.**
- Smaller pipe can have more flow.

Environmental Impact

- In 12 out of 13 environmental impact categories, BlazeMaster CPVC pipe and fittings outperform steel
- CPVC has a 1/3 higher ozone depletion impact due to the chlorofluorocarbons used in producing the PVC feedstock
- BlazeMaster CPVC pipe and fittings have half the climate change impact of steel



Talk Points:

- The environmental performance gap between BlazeMaster CPVC pipe and fittings and steel piping systems will likely get wider in the future.
- Although CPVC is recyclable, the LCA conservatively assumes no CPVC recycling, compared with the 100% recycling rate assumed for steel.
- As CPVC recycling infrastructure increases, the environmental performance advantage of BlazeMaster CPVC pipe and fittings over steel can be expected to become even larger.

BlazeMaster® FIRE PROTECTION SYSTEMS
Introduction V21.4

Upgrade to BlazeMaster in Areas of Aggressive Water

- Visual inspection is required for Steel per NFPA 25 - not needed for CPVC per **NFPA 25 14.2.1.5**
- 70% of corrosion in steel systems are found in the horizontal mains
- Schedule 10 steel pipe has a 47% life expectancy compared to Schedule 40 steel pipe yet it is the most common pipe used for mains

BlazeMaster Pipe & Fittings will remain corrosion-free for the life of the system

25-year-old Steel Pipe vs.
29-year-old BlazeMaster

MAIN MENU Version: 21.4 EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

Introduction V21.4

BlazeMaster Pipe and Fitting Manufacturers

Pipe

tyco Fire Protection Products

VIKING Trusted above all™

IPEX Committed to Excellence (Canada Only)

Fittings

tyco Fire Protection Products

VIKING Trusted above all™

IPEX Committed to Excellence (Canada Only)

MAIN MENU **Version:** 21.4 EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

V21.4

Standards, Codes & Approvals

After completing this module, you will be able to:

- Identify the difference between light and ordinary hazard occupancies
- List what types of buildings for which BlazeMaster is approved

Click for more information

BlazeMaster Listings and Approvals

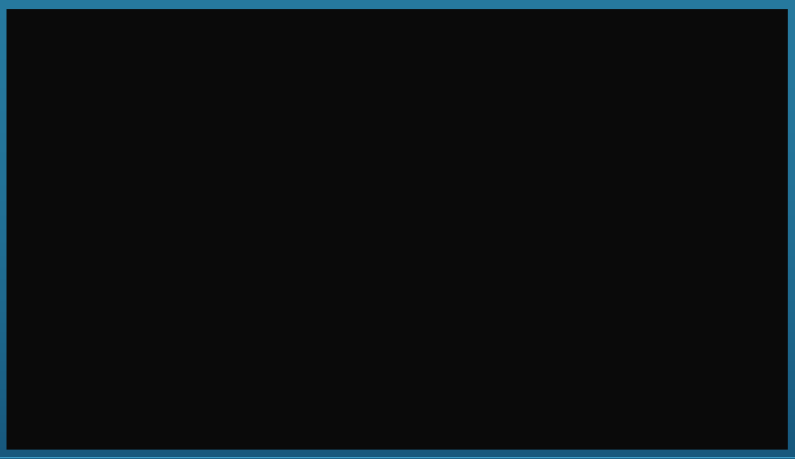
Building Codes

MAIN MENU **Version:** 21.4EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Fire Test Video



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BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Listed for Fire Protection Systems

- BlazeMaster pipe and fittings are specifically designed for Fire Protection Systems
  - Rated for continuous operation of 175 psi (1207 kPa) at 150°F (66°C)
  - The minimum requirement of the UL 1821 Standard is 175 psi (1207 kPa) at 120°F (49°C)
- Listed and approved to UL 1821 and FM 1635
  - (UL) Underwriters Laboratories
  - (FM) Factory Mutual Approvals

MAIN MENU Version: 21.4 EN

Talk Points:
-BlazeMaster pipe and fittings are suitable in areas where ambient temperatures are within the range of 35° (2°C) to 150° (66°C)
-BlazeMaster can be installed in areas such as an attic where the temperature will exceed 150° (66°C) if ventilation is provided or if insulation is used around the pipe.

BlazeMaster Approvals

- NFPA 13 – Light Hazard
- NFPA 13R
- NFPA 13D
- NFPA 24 – Underground Water Service

BlazeMaster® FIRE PROTECTION SYSTEMS
Standards, Codes & Approvals V21.4

Light Hazard

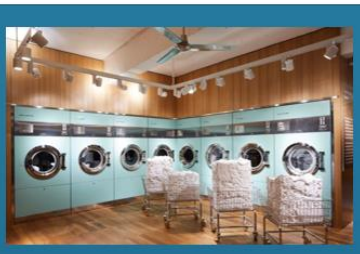
NFPA 13 – Light Hazard:
Combustibility of contents is low, quantity of the combustible is low, and low rates of heat release

- Places of Worship
- Clubs
- Educational (Schools / Student Housing)
- High Rises (Hotels / Condos over 4 stories)
- Hospitals
- Libraries
- Museums
- Nursing Homes
- Offices
- Theaters / Auditoriums

BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Ordinary Hazard



Ordinary Hazard Group 1:
Combustibility of the contents is low, quantity of the combustibles and heat release is moderate, and height of storage is 8 ft. (2m) or less

Examples: Kitchen, Laboratory, Mechanical Room, Laundry Room

NFPA 13 – Ordinary Hazard– Exception*:
Pipe or tube listed for light-hazard occupancies shall be permitted to be installed in ordinary-hazard rooms of otherwise light-hazard occupancies where the room does not exceed 400 ft² (37 m2).

Pipe or tube installed in accordance with above shall be permitted to be installed exposed, in accordance with their listing.

MAIN MENU Version: 21.4 EN

Talk Points:
- Pipe does not have to be concealed
- There aren't any restrictions as long as you follow the Manufacturer's Installation Instructions and the room is under 400ft² (37m²).
- BlazeMaster CPVC pipe and fittings are not listed for Ordinary Hazard applications except for the exception above.

BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Ordinary Hazard

NFPA 13R – Ordinary Hazard – Exception*

Pipe or tube listed for light-hazard occupancies shall be permitted to be installed in ordinary-hazard rooms of otherwise light-hazard occupancies where the room does not exceed 400 ft² (37 m2)

Pipe or tube installed in accordance with above shall be permitted to be installed exposed, in accordance with their listing

Pipe or tube listed for light-hazard occupancies shall be permitted to be installed above ordinary-hazard rooms under the following conditions:

(1) In rooms 400 ft² (37 m2) or less, piping shall be permitted to be installed either exposed in accordance with its listing or installed concealed behind a minimum of one layer of 3⁄8 in. (10 mm) thick gypsum wallboard or 1⁄2 in. (13 mm) thick plywood

(2) In rooms over 400 ft² (37 m2) piping shall be permitted to be installed concealed behind a minimum of one layer of 3⁄8 in. (10 mm) thick gypsum wallboard or 1⁄2 in. (13 mm) thick plywood

** Adopted by NFPA in 2019*

MAIN MENU **Version:** 21.4 EN

Talk Points:

- Pipe does not have to be concealed
- There aren't any restrictions as long as you follow the Manufacturer's Installation Instructions and the room is under 400ft² (37m²).
- BlazeMaster CPVC pipe and fittings are not listed for Ordinary Hazard applications except for the exception above.

BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Garages

- NFPA 13R Standard
  - Concealed only
- Not required in NFPA 13D Standard, but may be added per the local jurisdiction
  - Example – California Residential Code requires garage protection
- Adopted by NFPA 13 2019 Edition:
  - Where nonmetallic pipe installed in accordance with the above supplies sprinklers in a private garage within a dwelling unit not exceeding 1000 ft² (93 m2) in area, it shall be permitted to be protected from the garage compartment by not less than the same wall or ceiling sheathing that is required by the applicable building code.

MAIN MENU **Version:** 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Occupancy Classifications

NFPA 13R – Residential
(Up to and including 4 stories)

- Multi-Family / Multi-Story Units
- Hotel / Motel
- Apartments
- Condominiums / Townhouses
- Student housing

MAIN MENU **Version:** 21.4 EN

Talk Points:

- Adopted by NFPA in 1989.

BlazeMaster® FIRE PROTECTION SYSTEMS

Standards, Codes & Approvals V21.4

Occupancy Classifications

NFPA 13D

- One / Two Family Dwellings
- Mobile / Manufactured Homes

MAIN MENU **Version:** 21.4 EN

Talk Points:

- Adopted by NFPA in 1975
- This includes townhouses that are one- and two-family dwellings

Pipe and Fittings ASTM Standards

- Pipe produced in SDR (Standard Dimension Ratio) 13.5 Iron Pipe Size
- Pipe and Fittings manufactured per ASTM standards
- BlazeMaster is the only pipe approved to meet a 25% higher pressure rating at 180°F (82°C), translating to a more robust and durable system
  - BlazeMaster CPVC: 4120-06 | 320 psi (2206 kPa) at 73°F (23°C) & 100 psi (689 kPa) at 180°F (82°C)
  - Non BlazeMaster CPVC: 4120-05 | 320 psi (2206 kPa) at 73°F (23°C) & 80 psi (551 kPa) at 180° F (82°C)

MAIN MENU Version: 21.4 EN

Talk Points:

- SDR (Standard Dimension Ratio) means that there is a constant ratio between the wall thickness of the pipe and the outside diameter of the pipe.
- The higher the SDR, the thinner the wall (i.e. and SDR 9 pipe has a thicker wall and an SDR 11 pipe).
- The result of SDR pipe is that all sizes have the same temperature/pressure rating.

Why This is Important

- CPVC 4120-06 SDR 13.5 pipe is rated for 100 psi (689 kPa) at 180°F (82°C) which is a requirement for most model plumbing codes to be used in potable water applications
- NFPA 13D permits the use of full flow-through and partial flow-through sprinkler systems, utilizing the domestic cold-water supply
- Local plumbing code requirements must be adhered to
- BlazeMaster is the only CPVC permitted for use in these applications

Talk Points:

- BlazeMaster is certified for potable water and multi-purpose systems.

BlazeMaster® FIRE PROTECTION SYSTEMS
Standards, Codes & Approvals V21.4

Standards, Codes & Approvals

- UL (Underwriters Laboratories) and UL-C listed
- NSF certified for potable water
- FM (Factory Mutual) Approved*
- Meets the requirements of all major model building codes

*FM Approved – 1635 – Plastic Pipe & Ftngs AS Sys

MAIN MENU Version: 21.4 EN

Knowledge Check!

"What are examples of Light & Ordinary Hazard?"

MAIN MENU Version: 21.4 EN

Instructor Action: Ask Questions
Q: ***"What are examples of Light Hazard Occupancies?***
A: Apartments, single family homes, Hotels, condos, Student Housing, Clubs, churches, high rises, libraries, nursing homes, offices, Hospitals Etc.

Q: ***"What are examples of Ordinary Hazard Occupancies?***
A: Kitchen, Stock Room, Mechanical Room, etc.

Further discussion:
Q: ***"Can BlazeMaster be used in Ordinary Hazard"***
A: Only if the room does not exceed 400 sq. ft.

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V21.4

Installation Best Practices

After completing this module, you will be able to:

- Identify how to store and handle BlazeMaster pipe, fittings and solvent cement
- Recognize appropriate safety precautions

Click for more information

Handling and Storage

Health and Safety Precautions

MAIN MENU Version: 21.4EN

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Material Handling

- Material handling best practices applies to **all** material types
- Poor practices can lead to damaged material and potential system failures

MAIN MENU Version: 21.4 EN

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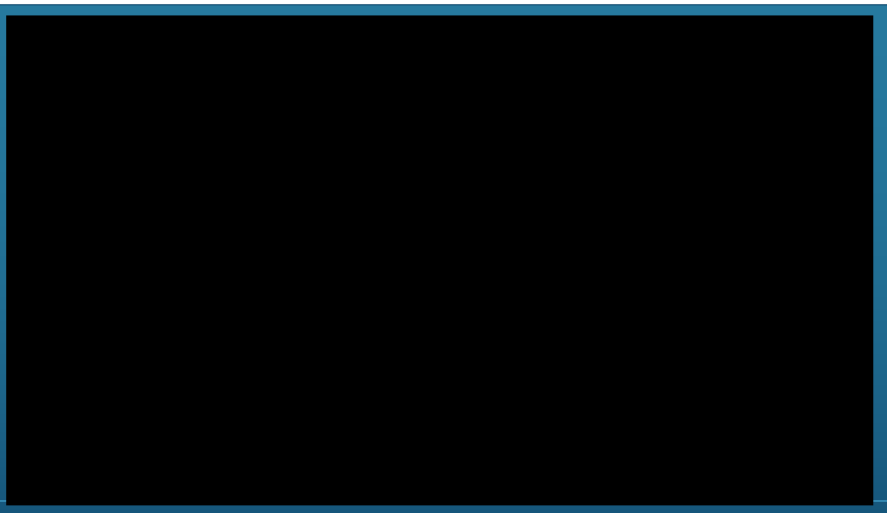
Installation Best Practices V21.4

Handling and Storage Video



MAIN MENU Version: 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Installation Best Practices V21.4

BlazeMaster Pipe & Fittings Handling & Storage

Best Practices

- ✓ Pipe and fittings should remain protected in original cartons to minimize damage and maintain cleanliness.
- ✓ Pipe should be inspected for splits, cuts and gouges.
- ✓ Pipe stored outside should be covered to avoid sunlight.
- ✓ Fittings should never be thrown to the ground.
- ✓ Pipe should never be dropped or dragged.
- ✓ Avoid contamination of pipe and fittings with non-compatible petroleum-based products such as cutting or packing oils.
- ✓ Additional care should be taken in cold climates to prevent pipe and fitting damage.

MAIN MENU Version: 21.4 EN

Instructor Actions:
Step 1: Bring up slide and ask **Q:** ***"After watching the videos, what are some of the best practices that were listed?"***
Step 2: After the audience gives all their answers **then "CLICK"** bringing up checklist
Step 3: "Click" to check off each box in sequence and discuss each answer briefly as you check it off. **If it is an answer that was missed, be sure to emphasize its importance, reinforcing the learning.**

Congratulate the audience for the correct answers they gave especially if all were correct!

Solvent Cement Storage and Handling

- **Do**
  - Store between 40°- 110°F (4 - 43°C) or as specified on label
  - Keep containers closed and covered as much as possible
  - Use in well ventilated area
- **Don't**
  - Store near heat, sparks, open flames and other sources of ignition
  - Smoke, eat or drink while using these products
  - Put in contact with skin, eyes and clothing

Shelf life: 2 years from the production date

Date code varies per manufacturer and can be found on the bottom of the can

MAIN MENU Version: 21.4 EN

Talk Points:

- Shelf life is 2 years from the production date which can be found on the bottom of the can.
  - Date codes vary by manufacturer
- Store between 40°- 110°F (5 - 43°C) or as specified on label.
- Do not store near heat, sparks, open flames and other sources of ignition.
- Keep containers closed when not in use and covered as much as possible when in use.
- Use in well-ventilated area.
- Do not smoke, eat or drink while using these products.
- Avoid contact with skin, eyes and clothing.
- Date code format varies by manufacturer.

Cold Weather Applications – Solvent Cement

- Store bulk quantities of cement in a warm location above 40°F (4ºC)
- If solvent cement is stored at a very cold temperature and gels:
  - Bring into a warm environment (60°F - 90°F / 16ºC - 32ºC) and allow it to sit for 24 hours
  - Do not try to artificially heat it
  - Before use, vigorously shake the solvent cement

MAIN MENU Version: 21.4 EN

Suggestion: "Make this a part of the Best Practice Check list for their "on the job support".

Talk Points:

- Prefabricate as much of the system as possible in a heated work area
- Store bulk quantities of primer and cement in a warm location above 40°F (4ºC) when not in use.
  - Make sure they remain fluid.
- If solvent cement gels:
  - Bring into a warm environment (60°F - 90°F / 16ºC - 32ºC) and allow it to sit for 24 hours.
  - Do not try to artificially heat it.
  - Before use, vigorously shake the solvent cement.

BlazeMaster® FIRE PROTECTION SYSTEMS

Installation Best Practices V21.4

Cold Weather Applications – Pipe & Fittings

- Can be installed down to 0°F (-18°C), but best to install in a heated environment, when possible
- Ensure that the pipe, fittings, and valves are at the same temperature prior to solvent welding
- Remove moisture including ice and snow from the pipe and fittings
- Allow a longer cure period before the system is pressure tested

MAIN MENU Version: 21.4 EN

Talk Points:

- Prefabricate as much of the system as possible in a heated work area.
- Store bulk quantities of primer and cement in a warm location above 40°F (4°C) when not in use.
    - Make sure they remain fluid.
- If solvent cement gels:
    - Bring into a warm environment (60°F - 90°F / 16°C - 32°C) and allow it to sit for 24 hours.
    - Do not try to artificially heat it.
    - Before use, vigorously shake the solvent cement.

High Temperature Installations

- Solvent cement evaporates more quickly in high temperatures, so ensure the solvent is wet before joining pipe and fittings
- This can be a bigger issue with the large diameter piping
- For more information, refer to Manufacturer's Installation Instructions

BlazeMaster® FIRE PROTECTION SYSTEMS
Installation Best Practices V21.4

Health and Safety Precautions

- Provide ventilation or NIOSH approved respirator if necessary
- Wear proper protective clothing including gloves and safety goggles while solvent welding
- Wear a dust mask when cutting BlazeMaster pipe with a power saw
- Refer to ASTM F402 for additional recommendations

MAIN MENU Version: 21.4 EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

V21.4

Chemical Compatibility

After completing this module, you will be able to:

- Recall the best practices associated with chemical compatibility
- Recognize where to find information on the products that are compatible with BlazeMaster Fire Protection Systems

Click for more information

Chemical Compatibility

FBC™ System Compatible Program

MAIN MENU **Version:** 21.4EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

Chemical Compatibility V21.4

Chemical Compatibility Video

MAIN MENU **Version:** 21.4 EN

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

Chemical Compatibility

- CPVC can be damaged by contact with chemicals found in some construction products such as:
  - Edible oils
  - Petroleum – or solvent-based sealants
  - Lubricants or firestop materials
  - Glycol-based antifreeze
  - Reference www.fbcsystemcompatible.com for complete list

MAIN MENU Version: 21.4 EN

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

Talk Points:

- NFPA recognizes chemical compatibility is a concern and recommends verifying compatibility with the Manufacturer of the product and/or referencing the **FBC™ System Compatible** website
- When on a BlazeMaster Fire Sprinkler System job and you see something attached to or touching the pipe or fitting, you should assume it is not compatible and check in to its compatibility yourself or advise the proper authority.

Talk Points

- The testing is specific to Lubrizol's CPVC products and the FBC System Compatible program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan CPVC piping systems
- Look for the "FBC™ System Compatible" logo on ancillary product labels to ensure chemical compatibility
- Actively used in the U.S., Canada, Mexico, 25 European countries, the United Arab Emirates, India and China
- Lubrizol cannot guarantee that these products will be compatible with CPVC from other manufacturers.
- The manufacturers of products in the Program agree to not change the formulation of their product unless they notify Lubrizol and submit the revised produce for compatibility testing.,
- A third-party certification lab audits the manufacturing sites annually and verifies the formulation.

BlazeMaster® FIRE PROTECTION SYSTEMS

Chemical Compatibility V21.4

FBC System Compatible Resources

- **fbcsystemcompatible.com** includes:
  - Lists of Compatible & Incompatible products
  - "Other Chemical Compatibility Topics" section provides guidance on determining compatibility of materials not on the lists
  - "Understanding Chemical Compatibility" videos
- **FBC System Compatible Product Finder App**
  - Available for apple and android devices
- If it is not on the website or app, check with the product's Manufacturer for chemical compatibility

www.fbcsystemcompatible.com

MAIN MENU Version: 21.4 EN

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

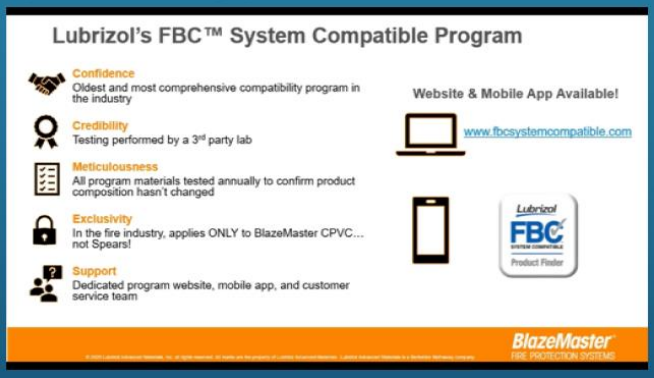
Talk Points:

- "Understanding Chemical Compatibility" videos viewed on the website give a more in-depth understanding of chemical compatibility.
- What is chemically compatible with BlazeMaster CPVC
- Products and chemicals known to be incompatible with BlazeMaster CPVC
- Other Compatibility Topics
- Download the new **FBC System Compatible Product Finder** app for access to our new chemical compatibility videos and tools
- If it is not on the website, always check with the product's Manufacturer for chemical compatibility

BlazeMaster® FIRE PROTECTION SYSTEMS

Chemical Compatibility V21.4

FBC System Compatible App Demo Video



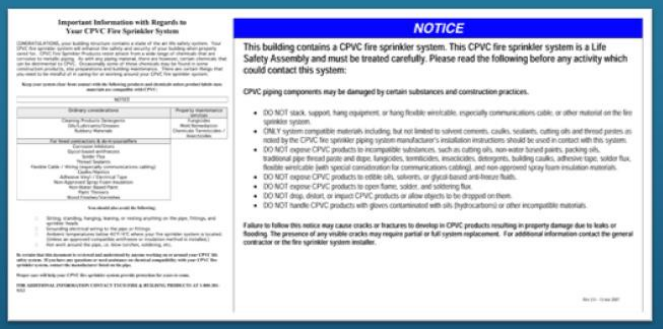
MAIN MENU Version: 21.4 EN

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

Check Manufacturer's websites for additional literature

Jobsite Proposal and OEM Documents

- These are found on all jobsites
- Address chemical compatibility
- Storage and handling



Important Information with Regards to Your CPVC Fire Sprinkler System

NOTICE

This building contains a CPVC fire sprinkler system. This CPVC fire sprinkler system is a Life Safety Assembly and must be treated carefully. Please read the following before any activity which could contact this system:

CPVC piping components may be damaged by certain substances and construction practices.

- DO NOT stack, support, hang equipment, or hang flexible wire/cable, especially communications cable, or other material on the fire sprinkler system.
- ONLY system compatible materials including, but not limited to solvent cements, caulks, sealants, cutting oils and thread pastes as noted by the CPVC fire sprinkler piping system manufacturer's installation instructions should be used in contact with this system.
- DO NOT expose CPVC products to incompatible substances, such as cutting oils, non-water based paints, packing oils, traditional pipe thread paste and dope, fungicides, termiticides, insecticides, detergents, building caulks, adhesive tape, solder flux, flexible wire/cable (with special consideration for communications cabling), and non-approved spray foam insulation materials.
- DO NOT expose CPVC products to edible oils, solvents, or glycol-based anti-freeze fluids.
- DO NOT expose CPVC products to open flame, solder, and soldering flux.
- DO NOT drop, distort, or impact CPVC products or allow objects to be dropped on them.
- DO NOT handle CPVC products with gloves contaminated with oils (hydrocarbons) or other incompatible materials.

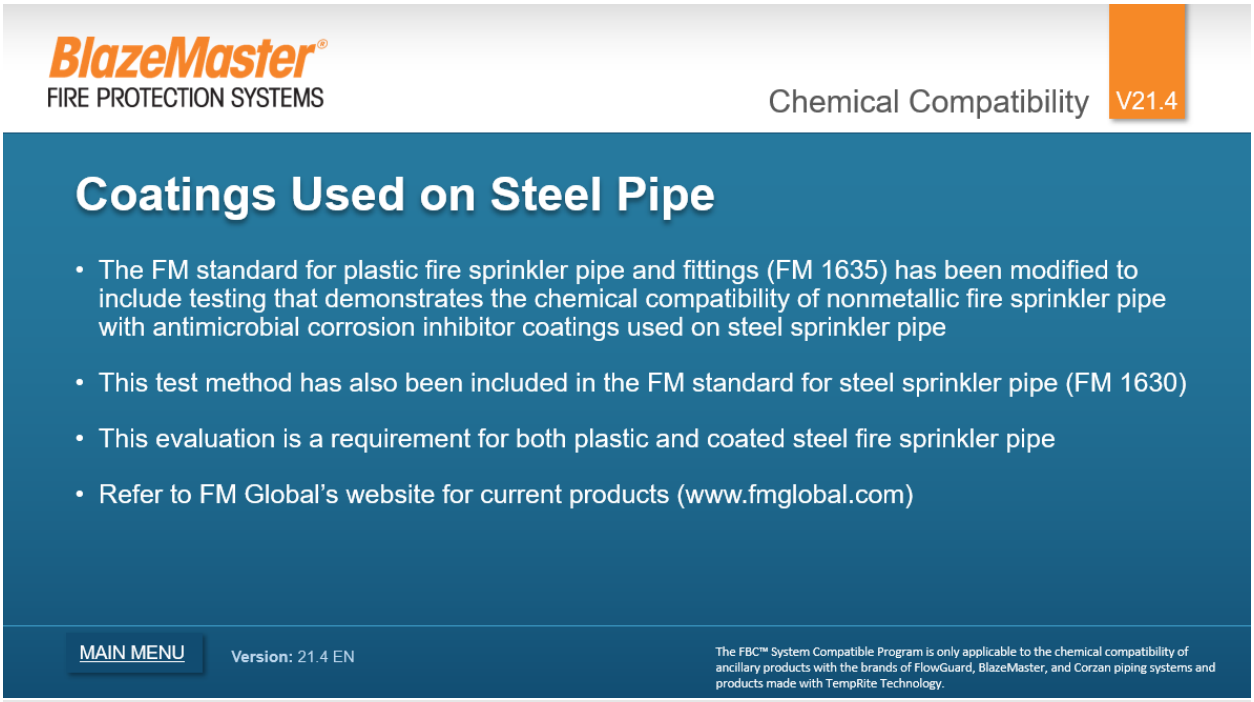
Failure to follow this notice may cause cracks or fractures to develop in CPVC products resulting in property damage due to leaks or flooding. The presence of any visible cracks may require partial or full system replacement. For additional information contact the general contractor or the fire sprinkler system installer.

MAIN MENU Version: 21.4 EN

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

Talk Points:

- These two notices can also be found on the jobsite and should be used to notify the General Contractor who will then notify the other trades.
- These turnover documents are critical to your protection.



Talk Points:

- The FM standard for plastic fire sprinkler pipe and fittings (FM 1635) has been modified to include testing that demonstrates the chemical compatibility of nonmetallic fire sprinkler pipe with coatings used on steel sprinkler pipe.
- This test method has also been included in the FM standard for steel sprinkler pipe (FM 1630).
- This evaluation is a requirement for both plastic and coated steel fire sprinkler pipe.
- Refer to FM Global's website for current products.

BlazeMaster® FIRE PROTECTION SYSTEMS

Chemical Compatibility V21.4

Chemical Compatibility

Best Practices – Chemical Compatibility

- ✓ Look for the "FBC System Compatible" logo on ancillary product labels to ensure chemical compatibility.
- ✓ Verify chemical compatibility with the Manufacturer of the product and/or check FBC™ System Compatible web site.
- ✓ Download the **FBC System Compatible Product Finder** app for access to our chemical compatibility videos and tools.

MAIN MENU **Version:** 21.4 EN

Instructor Actions
Step 1: Ask a second Q: ***"If you have a concern about chemical compatibility what should you do?"***
Step 2: After the audience gives all their answers **then "CLICK"** bringing up 2nd part of checklist .
Step 3: "Click" to check off each box in sequence and discuss each answer briefly as you check it off.
- **If it is an answer that was missed, be sure to emphasize its importance, reinforcing the learning.**

BlazeMaster® FIRE PROTECTION SYSTEMS

V21.4

Cut and Join

After completing this module, you will be able to:
- Perform proper cutting and joint preparations
- Perform the solvent welding process
- Know the right way to install a sprinkler head
- Explain how to use tape sealants

Click for more information

Cut and Join Overview
Exercise
Set and Cure Times
Pressure Test
Cut-In Procedure

MAIN MENU **Version:** 21.4EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Cut and Join Video

Refer to Manufacturer's Installation Instructions regarding dauber sizes prior to use.

MAIN MENU Version: 21.4 EN

Talk Points:

- Let's begin this module with a video showing you how to cut, join and assemble BlazeMaster Sprinkler Pipe.

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Fitting Preparation

- The pipe should enter the fitting socket easily 1/3 to 2/3 of the way
- Using a clean, dry rag, wipe loose dirt and moisture from the fitting socket and pipe end
- **Caution:** Dry fits (Neglecting to use solvent cement) can cause significant damage after system is pressurized!

MAIN MENU Version: 21.4 EN

Talk Points:

- Due to the taper on the ID of the fitting, most of the strength of the joint is in the last ¼" of the fitting socket.
- A "dry fit" is when the installer forgets to put solvent cement on the joint. The joint may hold an initial pressure test (because of the interference fit between the pipe and fitting), but long term, it will fail and cause water damage.

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Using Ratchet Cutters

- Care must be exercised! Ratchet cutters may split the pipe if not used properly and maintained
- Must contain a sharp blade
- Only use when temperatures are at 50°F (10°C) or warmer
- Must be of good quality, capable of consistently cutting the pipe squarely
- Failure to follow any of the above directions may result in leakage or property damage

MAIN MENU Version: 21.4 EN

Talk Points:

- Keep blades sharp. Ratchet-style cutters tend to compress the pipe when blades are dull, which could create problems, particularly in cold weather.

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

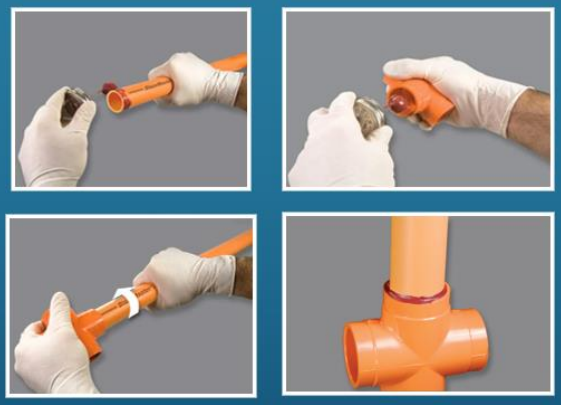
Daubers for Solvent Cement

- Use a dauber that is properly sized for the pipe
- Larger daubers come in the quart can
- Smaller daubers come in the pint can
- Smaller daubers are generally available at various locations
- The proper size dauber is very important to prevent puddling
- Refer to Manufacturer's Installation Instructions regarding dauber sizes prior to use

MAIN MENU Version: 21.4 EN

Cut & Join Recap

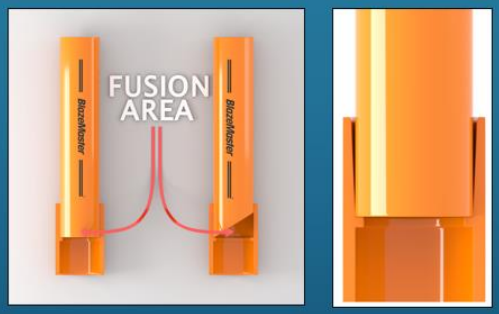
- Cut pipe squarely
- Deburr inside/bevel outside of pipe
- Fit the pipe
- Apply cement to the outside of pipe
- Apply cement (without double dipping) to the inside of the fitting socket
  - On sizes 1-1/4" (32mm) and larger - Dip cement and apply to the pipe again
- Insert pipe end into socket while rotating the pipe a ¼ turn and hold for 30 seconds



BlazeMaster® FIRE PROTECTION SYSTEMS
Cut and Join V21.4

Interference Fit

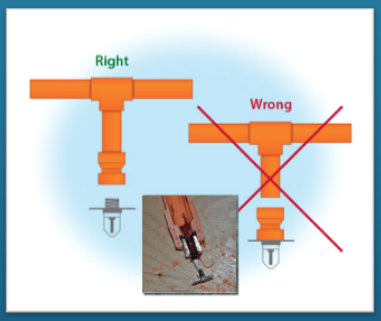
- The bottom 1/3 of the fitting is the most important part of the joint as this is where the fitting interference occurs. This is also the fusion area
- It is important to cut squarely
- **ALWAYS** cut pipe straight
- **ALWAYS** push the pipe the entire way into the fitting
- **ALWAYS** hold for the entire recommended "set time"
- **WHEN POSSIBLE,** perform a quarter-turn when pipe is inserted on small sizes



MAIN MENU Version: 21.4 EN

Sprinkler Head Adapters Installation

- Install the sprinkler head after the sprinkler head adapter has been solvent welded
- Ensure waterway is not obstructed
- Anticipate the future finishing of a wall or ceiling
- Care must be taken to avoid over torqueing
- Refer to the Manufacturer's Installation Instructions



Sprinkler head can get clogged with cement if you attach head before fitting connection.

Talk Points:

- Sprinkler head adapters are manufactured with a brass thread insert to provide a high strength, heavy duty fitting for threaded connections with male metal threads.
- Sprinkler heads may be installed only after all the fire sprinkler fittings, including the sprinkler head adapters, are solvent welded to the piping and have been allowed to cure as recommended in the cure chart.
- Plastic threaded plugs are available for use in pressure testing.
- The sprinkler head fittings should be visually inspected or probed with a wooden dowel to ensure waterway and threads are clear of any excess cement.

BlazeMaster® FIRE PROTECTION SYSTEMS
Cut and Join V21.4

Using Tape or Paste Sealants With Metal Threads Best Practices

- Joint Assembly:
  - Wrap tape in direction of threads. Clockwise for right-hand thread
- Sprinkler head adapters:
  - Use 2-3 wraps of tape and tighten to specified torque
- Tighten threaded joints 1-2 turns beyond finger tight
- Do not over-tighten

MAIN MENU Version: 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Thread Sealants

Use only Teflon® tape or chemically compatible thread sealant

- Do not use both at the same time
- Care must be taken to avoid over torqueing
- Refer to the Manufacturer's Installation Instructions

MAIN MENU Version: 21.4 EN

Talk Points:

- Usually, 1 to 2 turns beyond finger tight is all that is required to make up a threaded connection.

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

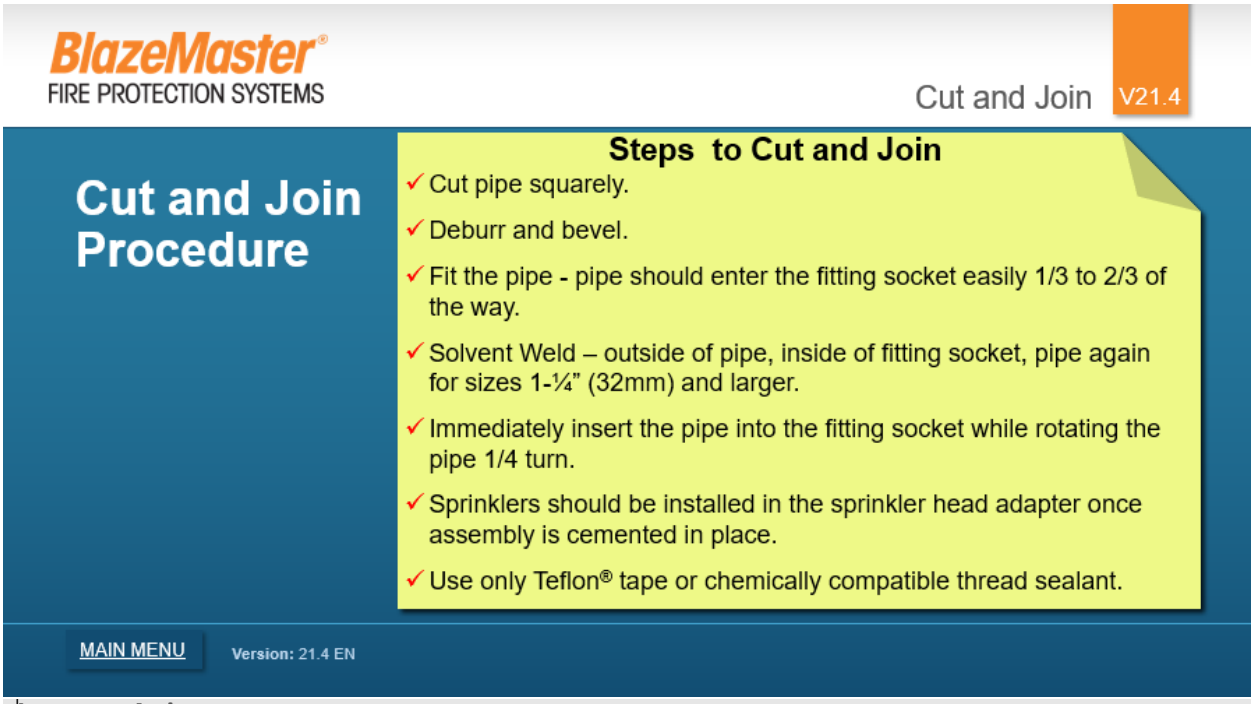
Gasket Head Adapters

- Eliminate pipe dope and Teflon tape
- Eliminate the need for torque wrenches when installing sprinkler heads

MAIN MENU Version: 21.4 EN

Talk Points:

- This has been a point of concern and our partners have eliminated this issue with the development of these head adapters.
- The seal point is now the gasket instead of the threads.



Instructor Actions:

- Bring up slide
- Ask Question: ***"What is the first step to assembly?"***
- After you receive an answer **"CLICK"** bringing up first step.
- Confirm if answer is correct or not, Elaborate on any points as needed. See Talk Points for more information.
- Ask: **"Next step?"** and move through list same as above using Talk Points

Talk Points

1. Cutting - Cut pipe squarely using a ratchet cutter, a wheel-type plastic tubing cutter, a power saw or a fine-toothed saw.
2. Deburr and bevel
    - Use a chamfering tool or other tool to remove burrs and filings from the inside and outside of the pipe.
    - Slight bevel on the OD of pipe approx. 10-15°
    - After chamfering, use a clean, dry rag to remove any loose burs and filings.
3. Pipe Fitting
    - The pipe should enter the fitting socket easily 1/3 to 2/3 of the way.
    - Using a clean, dry rag, wipe loose dirt and moisture from the fitting socket and pipe end.
    - **Caution:** Dry fits can cause significant damage after system is pressurized!
4. Solvent Weld
    - Apply solvent cement to OD of pipe using a brush or a dauber.
    - Apply solvent cement to the fitting socket. Do not puddle the cement in fitting.
    - Apply another application of solvent cement to pipe 1-1/4" (31.75mm) and larger.
5. Assemble
    - Immediately insert the pipe into the fitting socket while rotating the pipe 1/4 turn. This ensures against potential "leak" tracks in the solvent cement.
    - Make sure that the pipe bottoms in the socket and hold for 30 seconds to ensure the pipe will not back out.
    - A bead of solvent cement should be evident around the pipe and fitting juncture.
6. Where solvent cement is used as the pipe and fittings bonding agent, sprinklers shall not be installed in the fittings prior to the fittings being cemented in place.
7. Joint Assembly: Wrap tape in direction of threads. Clockwise for right-hand thread
    - Sprinkler head adapters: Use 2-3 wraps of tape and tighten to specified torque.
    - Tighten threaded joints 1-2 turns beyond finger tight.
    - Do not over-tighten.

Set and Cure Times

- Cure times are a function of:
  - Pipe size and length
  - System pressure
  - Temperature
  - Humidity
- The assembly must be allowed to set without any stress on the joint for one (1) to five (5) minutes
- The system should not be pressure tested until minimum cure times have been met
- Refer to Manufacturer Installation Instructions for required set and cure times

MAIN MENU Version: 21.4 EN

Talk Points:

- Three cure charts have been developed – 225 psi, 200 psi and 100 psi.
- The higher the test pressure, the longer the cure time. Pipe size and colder temperatures also increase cure time.
- NFPA 13 requires a 200 psi test or a test 50 psi above the static pressure, whichever is greater. Therefore, the highest-pressure test required is 225 psi. Systems with a static pressure at 150 psi or less will be tested at 200 psi.
- NFPA 13D permits systems in one- and two-family dwellings to be tested at line pressure. Line pressure in the United States will be 100 psi or less.
- **NOTE**: Cure times are for ideal conditions. If working in wet conditions or if cutting in to existing lines, the cure time may significantly increase.
- Refer to Manufacturer's cure tables for proper cure times.

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Cure Time Chart

TABLE I

Pipe Size	225 psi (1552 kPa) Test Pressure (maximum) Ambient Temperature During Cure Period		
	60°F to 120°F (16°C to 49°C)	40°F to 59°F (4°C to 15°C)	0°F to 39°F (-18°C to 4°C)
3/4" (20 mm)	1 hr.	4 hrs.	48 hrs.
1" (25 mm)	1 1/2 hrs.	4 hrs.	48 hrs.
1 1/4" & 1 1/2" (32 & 40 mm)	3 hrs.	32 hrs.	10 days
2" (50 mm)	8 hrs.	48 hrs.	Note 1
2 1/2" & 3" (65 & 80 mm)	24 hrs.	96 hrs.	Note 1

TABLE II

Pipe Size	200 psi (1379 kPa) Test Pressure (maximum) Ambient Temperature During Cure Period		
	60°F to 120°F (16°C to 49°C)	40°F to 59°F (4°C to 15°C)	0°F to 39°F (-18°C to 4°C)
3/4" (20 mm)	45 mins.	1 1/2 hrs.	24 hrs.
1" (25 mm)	45 mins.	1 1/2 hrs.	24 hrs.
1 1/4" & 1 1/2" (32 & 40 mm)	1 1/2 hrs.	16 hrs.	120 hrs.
2" (50 mm)	6 hrs.	36 hrs.	Note 1
2 1/2" & 3" (65 & 80 mm)	8 hrs.	72 hrs.	Note 1

TABLE III

Pipe Size	100 psi (690 kPa) Test Pressure (maximum) Ambient Temperature During Cure Period		
	60°F to 120°F (16°C to 49°C)	40°F to 59°F (4°C to 15°C)	0°F to 39°F (-18°C to 4°C)
3/4" (20 mm)	15 mins.	15 mins.	30 mins.
1" (25 mm)	15 mins.	30 mins.	30 mins.
1 1/4" (32 mm)	15 mins.	30 mins.	2 hrs.

For these sizes, the solvent cement can be applied at temperatures below 40°F (4.5°C), however, the sprinkler system temperature must be raised to a temperature of 40°F (4.5°C) or above and allowed to cure per the above recommendations prior to pressure testing

MAIN MENU **Version:** 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Pressure Testing

- Fill system slowly with water and bleed all air from highest and furthest sprinkler head
- Pressure test in accordance with NFPA standards
- If a leak is found, the fitting must be cut out and replaced
- Low pressure air testing may be used in some situations
- Refer to Manufacturer's Installation Instructions

MAIN MENU **Version:** 21.4 EN

Talk Points:

- Air or compressed gas should never be used for pressure testing. Refer to the Manufacturer's Installation Instructions.

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

Cut-In Procedure

- Cut into existing system first on the smallest diameter pipe, near the modification
- Drain the lines prior to solvent welding, using a drain vac
- Follow solvent welding procedures: Square cut to length / debur / bevel / dry / apply solvent cement / insert with ¼ turn
  - Use a new can of solvent cement when making cut-ins
  - **Reference cure time for cut-ins as these are different from a new installation**

MAIN MENU **Version:** 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Cut and Join V21.4

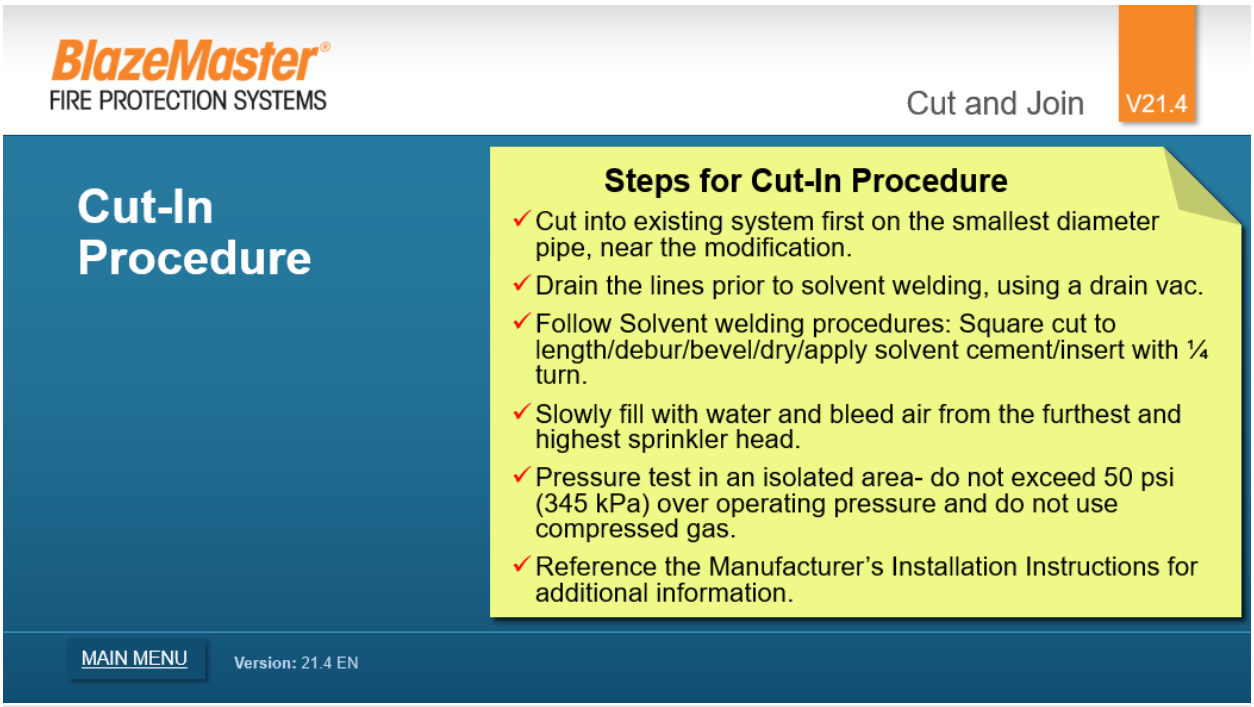
Cut-In Procedure

- Slowly fill with water and bleed air from the furthest and highest sprinkler head
- Pressure test in an isolated area - do not exceed 50 psi (345 kPa) over system operating pressure and do not use compressed gas
- Refer to the Manufacturer's UL-Approved cut-in procedure for additional information

MAIN MENU **Version:** 21.4 EN

Talk Points:

- After the work is completed and cut-in cure times are satisfied, inspect the work for proper alignment and hanger placement prior to pressure testing.
- After cut-in cure times are met, the system must be slowly filled with water and the air bled from the farthest and highest sprinkler heads before test pressure is applied (refer to Manufacturer's Installation Instructions regarding Hydrostatic Testing).
- Visually inspect the joint to make sure an even bead of cement is present. This should be completed to prevent a dry socket.

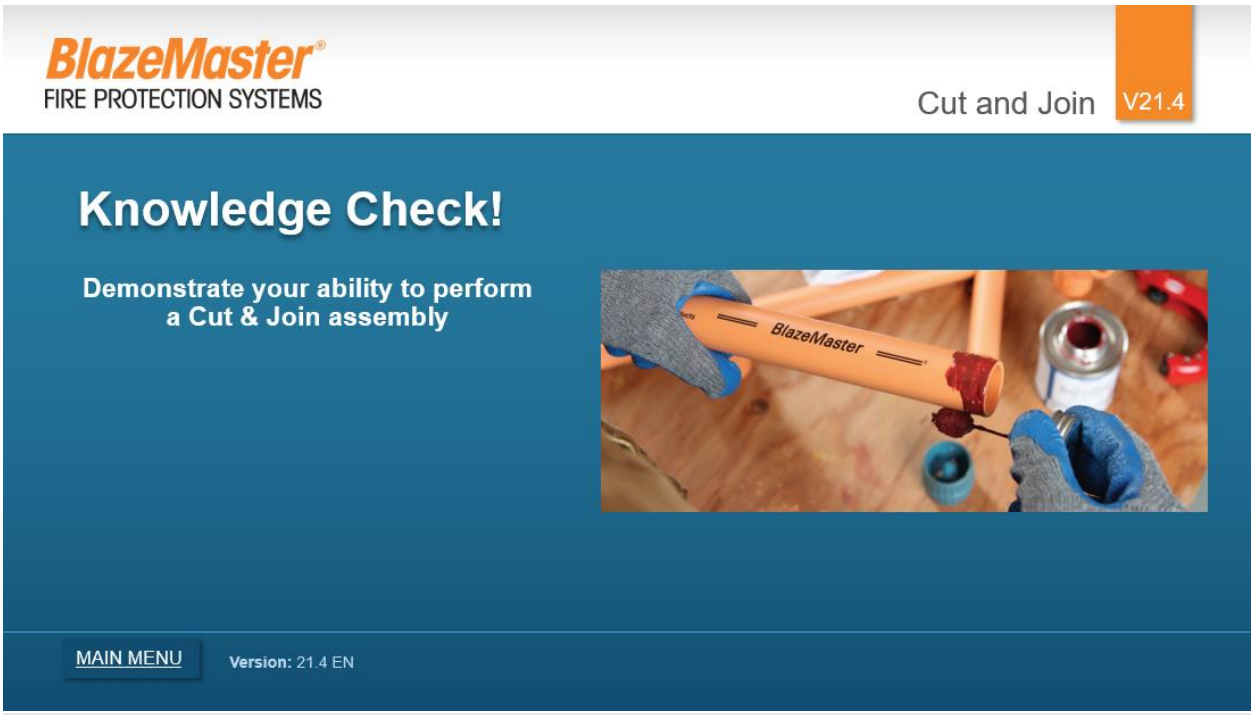


Instructor Actions:

- Bring up slide
- Ask Question**: *"What is the first step to doing a Cut-In?"***
- After you receive an answer **"CLICK"** bringing up first step.
- Confirm if answer is correct or not, Elaborate on any points as needed. See Talk Points for more information.
- Ask: **"Next step?"** and move through list same as above using Talk Points

Talk Points

- Cut into existing system first on the smallest diameter pipe, near the modification.
- Drain the lines prior to solvent cementing, using a drain vac.
- Follow Solvent cementing procedures: Square cut to length/debur/bevel/dry/insert with ¼ turn
    - Use a new can of solvent cement when making cut-ins.
    - Please be sure to reference cure times for cut-ins
- Slowly fill with water and bleed air from the furthest and highest sprinkler head
- Pressure test in an isolated area- do not exceed 50 psi and do not use compressed gas
- Please reference the manufacturer's installation instructions for additional information.



Exercise

Instructor Actions

1. Demonstrate how to perform a cut and join assembly.
2. Ask for a volunteer from the audience to perform the assembly.
3. Provide the participant with the materials. Give no instructions except for them to follow the proper steps to assemble the pipe.
4. Have class critique the assembly. Provide helpful feedback. Repeat the exercise, if needed.

MATERIALS

Pipe

8" (203mm) of 1" (25mm) diameter CPVC pipe

Fittings

1" (25mm) Tee

Sprinkler Head Adapter

1" (25mm) x 1/2" (13mm) NPT

Cement

Brush or dauber

Clean rag

Gloves

Additional Notes:

- You could throw in a few red herrings such as an expired cement to see if they check the date or choose another step that you think installers miss or do incorrectly on the job. This will reinforce those steps.
- If the exercise pipe is pre-cut. Ask the volunteer or someone else in the audience to go through the steps for cutting.
    - Cutting
    - Best practice for Ratchet Cutter
    - Deburring

BlazeMaster®
FIRE PROTECTION SYSTEMS

V21.4

Design Parameters

After completing this module, you will be able to:

- Explain how expansion and contraction can be accommodated
- Indicate proper methods for installing hangers
- Identify the differences of concealed vs. exposed installations
- List exposed installation types

Click for more information

Expansion and Contraction
Hangers and Supports
Riser Supports
Concealed vs. Exposed Installations

MAIN MENU **Version:** 21.4EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

Transitioning to Other Materials - Grooved Connections

- Use a flexible coupling
- Make sure the gasket is clean and free of any defects which may cause leaks
- Insure proper alignment of grooved adapter and steel pipe to minimize excessive strain or force on the BlazeMaster pipe
- Use a chemically compatible lubricant and gasket

MAIN MENU **Version:** 21.4 EN

Talk Points:

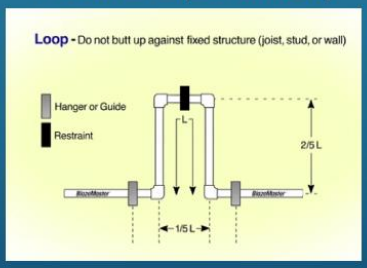
- If a lubricant (or other ancillary product) is not listed in the FBC™ System Compatible Program as being compatible or incompatible, contact the product manufacturer for more information.
- Chemical Compatibility is covered more in-depth in the Chemical Compatibility section of this presentation.
- CPVC is compatible with Nitrogen when it is used in hybrid systems. The earth's atmosphere is 78% nitrogen

Expansion and Contraction

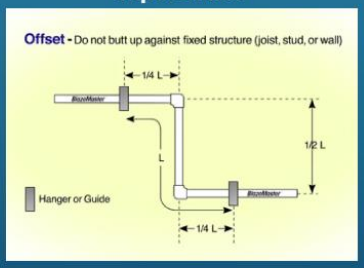
Expansion and contraction can be accommodated with:
Expansion Loop, Pipe Offset, Change in Direction

25°F (14˚C) change in temperature will cause an expansion of 1" (25mm) for a 100' (30.5m) straight length.

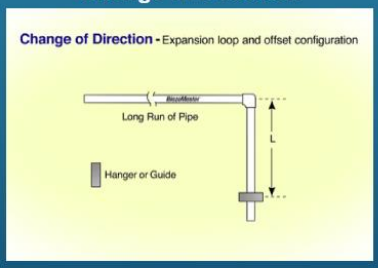
Restrained Expansion Loop



Pipe Offset



Change in Direction



MAIN MENU Version: 21.4 EN

Talk Points:

Restrained Expansion Loop

- The top hanger of the loop is darker in color because it is a fixed point.
- Allow for movement.
- Do not over-tighten hangers or straps.
- Do not butt against wall at changes in direction.
- If a system with long, straight runs (i.e., hallway) is installed in very cold weather, additional expansion loops may be necessary.
- Consult Manufacturer's Installation Instructions for proper spacing of expansion loops.

BlazeMaster® FIRE PROTECTION SYSTEMS

Design Parameters V21.4

Hangers and Supports

- Most UL Listed pipe hangers are suitable for BlazeMaster pipe and fittings
- UL Listed steel hangers are approved for use with BlazeMaster pipe if:
  - Hangers do not bind the BlazeMaster pipe from movement
  - Hangers do not have a rough or sharp edge that come in contact with the BlazeMaster pipe
- Pipe hangers must comply with the requirements of NFPA 13 and 13R (NFPA 13D does not require UL Listed hangers)
- Restraining clips are recommended, but not required
- Hangers must prevent **kickback** from sprinkler heads during discharge

MAIN MENU **Version:** 21.4 EN

Talk Points:

- Most UL Listed pipe hangers are suitable for CPVC pipe and fittings
- UL Listed steel hangers are approved for use with CPVC pipe if:
  - Hangers do not bind the CPVC pipe from movement (unless specifically UL Listed to do so)
  - Hangers do not have a rough or sharp edges that come in contact with the CPVC pipe
- *It is acceptable to cut holes in wood studs for support.*
  - *The holes should be oversized to allow for movement.*
- *Items such as plumber's tape and wire are NOT suitable hangers for use with BlazeMaster pipe.*
- Pipe hangers must comply with the requirements of NFPA 13 and 13R (NFPA 13D does not require UL Listed hangers)
- Restraining clips are recommended but not required
- Hangers must prevent **kickback** from sprinkler heads during discharge

Q: ***"Can anyone explain 'Kickback'?"***
A: Kickback is the reactive force of the water pressure when a sprinkler head is activated resulting in the pipe "kicking back" up in to the ceiling if not properly braced with a hanger support causing the sprinkler head deflector to not be effective.

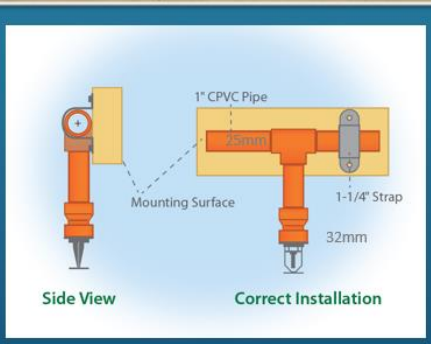
Protection When Running Through Metal Studs

- Stud inserts are available to protect BlazeMaster when running pipe through metal studs

Talk Point:
These products are available through the various manufactures of hangers designed for use with CPVC.

Hangers & Stress

- When BlazeMaster pipe is attached to a ceiling:
  - Don't use a hanger too small that it creates a deflection in the pipe (See picture)
- Pipe hangers tested for support of larger pipe sizes can be used to support smaller pipe sizes
  - Permitted by NFPA 13 and UL
  - The larger diameter of the hanger relieves some of the stress on the pipe



BlazeMaster® FIRE PROTECTION SYSTEMS

Design Parameters V21.4

Kickback

- Kickback is the reactive force of the water pressure when a sprinkler head is activated resulting in the pipe "kicking back" up into the ceiling if not properly braced with a hanger support causing the sprinkler head deflector to not be effective

MAIN MENU Version: 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Design Parameters V21.4

Hanger Support Spacing

- Standard pipe runs for all pressures

Nominal Size		Maximum Support Space	
Inches	Mm	Feet	Meters
3/4"	19	5-1/2	1.7
1"	25	6	1.8
1-1/4"	32	6-1/2	2.0
1-1/2"	38	7	2.1
2"	51	8	2.4
2-1/2"	64	9	2.7
3"	76	10	3.0

MAIN MENU Version: 21.4 EN

Talk Points:

- Three factors you need to size a hanger correctly are:
  - Pipe size
  - What the pipe is made of
  - Temperature of the fluid running through the pipe
- Spacing is important because if "kickback". We talked about "kickback" earlier.

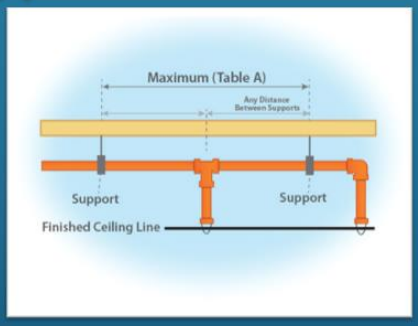
BlazeMaster®
FIRE PROTECTION SYSTEMS

Design Parameters V21.4

BlazeMaster In-Line Hanger Support

TABLE A
Maximum Support Spacing Distance In Line | *Sprinkler Head Drop Tee*

Nominal Pipe Size	Less than 100 psi (690 kPa)	More than 100 psi (690 kPa)
3/4" (19mm)	4' (1.2m)	3' (0.9m)
1" (25 mm)	5' (1.5m)	4' (1.2m)
1-1/4" (32mm)	6' (1.8m)	5' (1.5m)
1-1/2" -3" (38-76mm)	7' (2.1m)	7' (2.1m)



MAIN MENU **Version:** 21.4 EN

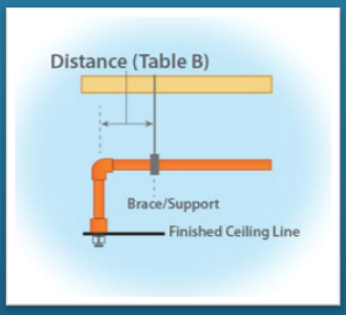
BlazeMaster®
FIRE PROTECTION SYSTEMS

Design Parameters V21.4

End of Line and Armover Hanger Support

TABLE B
Maximum Support Spacing Distance End Line | *Sprinkler Head Drop Elbow*

Nominal Pipe Size	Less than 100 psi (690 kPa)	More than 100 psi (690 kPa)
3/4" (19mm)	9" (229mm)	6" (152mm)
1" (25 mm)	12" (305mm)	9" (229mm)
1-1/4" (32mm)	16" (406mm)	12" (305mm)
1-1/2" -3" (38-76mm)	24" (610mm)	12" (305mm)



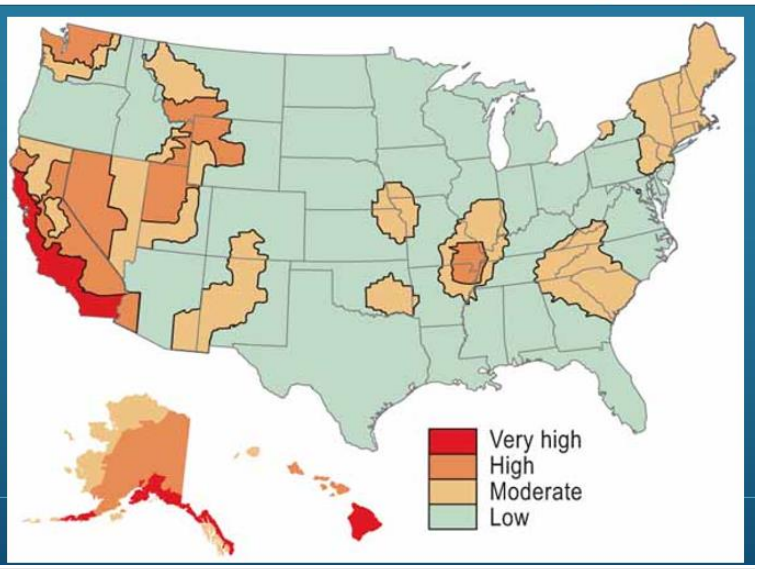
MAIN MENU **Version:** 21.4 EN

Talk Points:

- Sidewall head installed with a riser or a drop fall into this category.

Earthquake Bracing

- Requirements for seismic bracing should be done in accordance with NFPA 13 9.3 and Annex E
- Afcon, Loos & Company, and Tolco have products that are listed for use with CPVC and are OSHPD approved. Check with the manufacture for listing details



Talk Points:
- Follow the same guidelines as steel.

BlazeMaster® FIRE PROTECTION SYSTEMS
Design Parameters V21.4

Concealed Installations

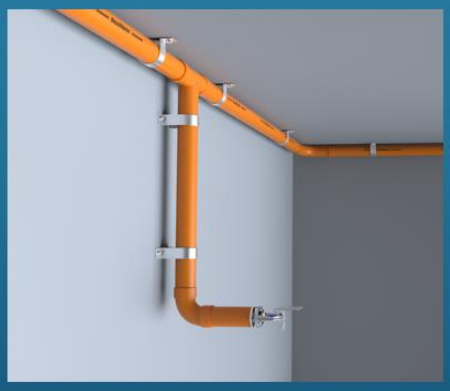
- BlazeMaster pipe and fittings shall be used in a concealed system application employing sprinkler heads rated at 225°F (107°C) or lower
- Minimum concealed protection shall consist of either:
  - a layer of 3/8" (10 mm) thick gypsum wallboard (sheetrock)
  - a suspended membrane ceiling with lay in panels or tiles having a weight of not less than 0.35 lbs. per square foot (159g per sq. meter) when installed with metallic support grids
  - a 1/2" (13mm) plywood soffit
- 90%+ of CPVC installations are concealed

BlazeMaster® FIRE PROTECTION SYSTEMS

Design Parameters V21.4

Exposed Installations

- Exposed installations (without protection)
  - Quick response sprinklers
  - Smooth, flat, horizontal ceiling
  - Decorative covering can be installed over exposed BlazeMaster pipe and fittings
  - Refer to Manufacturer's Installation Instructions



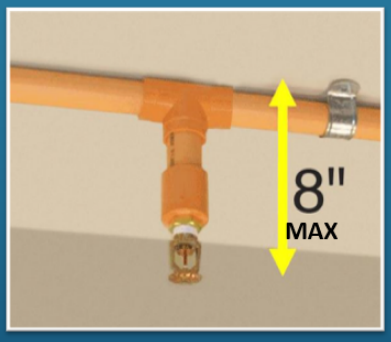
MAIN MENU **Version:** 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS

Design Parameters V21.4

Exposed Installations – Pendant Sprinklers

- Piping shall be mounted directly to the ceiling
- Deflector distance installed within 8" (203mm) from ceiling
- 170°F (77°C) maximum temperature rated
- Maximum distance between sprinklers shall not exceed **15**' (4.5m)



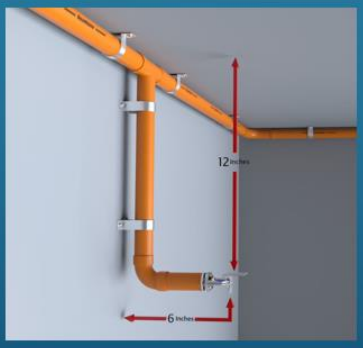
MAIN MENU **Version:** 21.4 EN

Talk Points:

- Pendant Sprinklers shall be Listed
- Piping shall be mounted directly to the ceiling.
- Deflector distance installed within 8" (203.2mm) from ceiling.
- 170°F (77°C) maximum temperature rated
- Maximum distance between sprinklers shall not exceed **15**' **(4.5m)**

Exposed Installations – Horizontal Sidewalls

- Piping shall be mounted directly to the wall
- Deflectors installed within **12**" (305mm) from the ceiling and within **6**" (152mm) from the sidewall
- Maximum distance between sprinklers shall not exceed **14**' (4.2m)
- 200°F (93°C) maximum temperature rated



MAIN MENU Version: 21.4 EN

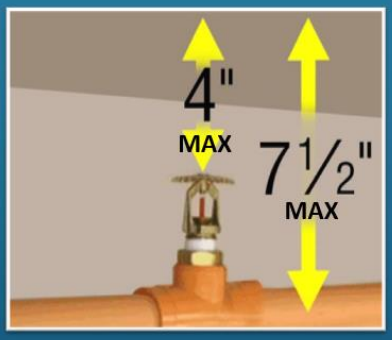
Talk Points:
- Horizontal Sidewall sprinklers shall be Listed
- Piping shall be mounted directly to the wall.
- Deflectors installed within **12**" **(305mm)** from the ceiling and within **6**" **(152mm)** from the sidewall
- Maximum distance between sprinklers shall not exceed **14**' **(4m)**
- 200°F (93°C) maximum temperature rated

BlazeMaster®
FIRE PROTECTION SYSTEMS

Design Parameters V21.4

Exposed Installations – Upright Sprinklers

- Smooth, flat, horizontal, fixed ceilings
- Standard Coverage Sprinklers
- 155°F (68°C) maximum temperature rated
- Sprinklers installed within **4“** (102mm) **f**rom ceiling
- Distance between sprinklers shall not exceed **15' (4.5m)**
- Ceiling to **centerline** of the main run of pipe shall not exceed **7-1/2”** (191mm)
- Centerline of the sprinkler head to the closest hanger shall be **3”** (76mm)



MAIN MENU Version: 21.4 EN

Talk Points:

- Upright Sprinklers shall be Listed
- Smooth, flat, horizontal, fixed ceilings
- Standard Coverage Sprinklers
- 155°F (68°C) maximum temperature rated
- Sprinklers installed within **4**" **(1012mm)** from ceiling
- Maximum distance between sprinklers shall not exceed **15**' **(4.5m)**
- Maximum distance from ceiling to centerline of the main run of pipe shall not exceed **7-1/2**" **(191mm)**
- Distance from the centerline of the sprinkler head to the closest hanger shall be **3**" **(76mm)**

Knowledge Check!

"How can expansion and contraction be accommodated?"

MAIN MENU Version: 21.4 EN

Q: *"Does anyone know how expansion can be accommodated?"*

A: Expansion can be accommodated with:

- Expansion loop
- Pipe offset
- Change in direction

BlazeMaster® FIRE PROTECTION SYSTEMS
V21.4

Special Listings & Circumstances

After completing this module, you will be able to:

- Identify how BlazeMaster can be used in attics
- Identify how BlazeMaster can be used in Plenums and other special circumstances

Click for more information

System Risers
Attic Spaces – NFPA 13
Composite and solid wood
Air Plenums
Special Listings
Freeze Protection

MAIN MENU Version: 21.4EN

Combustible Concealed Spaces

- Must not be installed in combustible concealed spaces requiring sprinklers, as referenced in NFPA 13, except when installed with specially UL Listed combustible concealed sprinkler heads
- Refer to the sprinkler head manufacturer's technical guides for information on applicable sprinkler heads for use with BlazeMaster
- NFPA 13R and 13D permit the omission of sprinklers from combustible concealed spaces and BlazeMaster pipe and fittings may be installed in these areas
- Refer to the Manufacturer's Installation Instructions

BlazeMaster® FIRE PROTECTION SYSTEMS
Special Listings & Circumstances V21.4

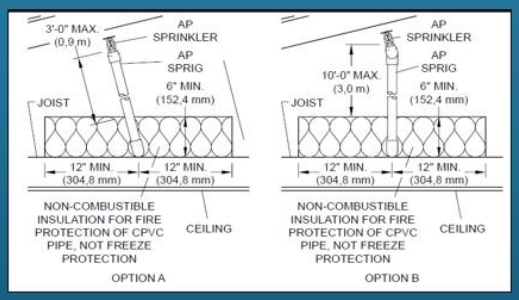
Attic Spaces - NFPA 13

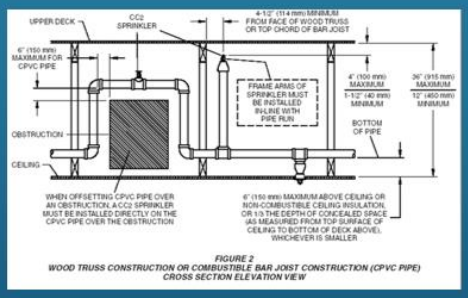
- Listed by UL for BlazeMaster pipe and fittings feeding the wet system sprinklers below the ceiling
  - if the attic is not required to be sprinklered

    or
  - if the attic is protected by specifically listed attic sprinklers
    - NOTE: BlazeMaster must be protected with 6" (152mm) of non-combustible insulation on top of the pipe when used with specifically listed attic sprinklers
    - Refer to the Manufacturer's Installation Instructions, NFPA 13 and consult with the AHJ prior to the installation

Attics & Combustible Concealed Spaces

When protecting combustible concealed spaces and attics, BlazeMaster CPVC is run low with sprigs to a fire sprinkler specifically listed for the application





BlazeMaster CPVC mains should be run low

MAIN MENU Version: 21.4 EN

BlazeMaster® FIRE PROTECTION SYSTEMS
Special Listings & Circumstances V21.4

Special Listings

- Low Pressure Dry System – 15psi (103kPa)
- Check with the Manufacturer's Installation Instructions for listing reference and additional information

MAIN MENU Version: 21.4 EN

Talk Points:
Some manufacturers offer low pressure, dry systems as an option to systems containing antifreeze.
NFPA requires a 24-hour air test at 40lbs. We do not recommend this, however the AHJ is allowed to accept our recommendation of 15 psi.

Basements: Solid & Composite Wood Joist Listing

- This listing is specific to BlazeMaster pipe and fittings
- UL listed for exposed use in basements *(adopted by NFPA in 2018)*
  - **Maximum sprinkler spacing is 16' (4.87 m) x 16' (4.87 m)**
  - **16" (406 mm) and smaller joists**
  - **Joist spacing is 24" (610 mm) and smaller**
  - **Ceiling height range is 7' (2.1 M) to 10' (3 m)**
  - **Blocking required every 40 feet**
  - **Can be installed parallel and perpendicular as per the Manufacturer's Installation Instructions**
  - **Deflector 1-¾" (44.5 mm) maximum below joist**

BlazeMaster® FIRE PROTECTION SYSTEMS
Special Listings & Circumstances V21.4

Air Plenums

- Listed by UL to the requirements of UL 1887 for use in return air plenums as defined by NFPA 90A, IMC (International Mechanical Code) and UMC (Uniform Mechanical Code)
- BlazeMaster pipe and fittings may be installed adjacent to ceiling openings such as a return grill but not over the opening

BlazeMaster® FIRE PROTECTION SYSTEMS

System Risers

- May be used as system risers in accordance with NFPA 13, 13R, and 13D when installed protected (concealed)
  - The minimum protection shall consist of either one layer of 3/8" (10mm) thick gypsum wallboard or 1/2" (13mm) thick plywood
- When installed without protection (exposed) additional limitations apply
- Exposed permitted for 13R and 13D
- Refer to the Manufacturer's Installation Instructions

Talk Points:

- This is acceptable for 13D, but it's not required.

BlazeMaster® FIRE PROTECTION SYSTEMS

Special Listings & Circumstances V21.4

Fire Sprinkler Drains

- Most people do not realize that BlazeMaster CPVC can be used for fire sprinkler drains as per NFPA 13
- Using BlazeMaster CPVC reduces fabrication and eliminates corrosion and failure of the drain lines to due corrosion

BlazeMaster®
FIRE PROTECTION SYSTEMS

V21.4

What's New

After completing this module, you will be able to:

- Understand BlazeMaster's listing for embedded in concrete applications
- Recognize freeze protection requirements

MAIN MENU Version: 21.4 EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

Embedded in Concrete

- BlazeMaster has a listing for embedding in concrete
- Refer to Manufacturer's Installation Instructions

MAIN MENU Version: 21.4 EN

Freeze Protection

- Insulation
  - Refer to the Manufacturer's Installation Instructions
- Existing systems
  - Antifreeze must be glycerin based
- New Systems:
  - 2013 NFPA states antifreeze solutions must be listed for use in sprinkler systems
  - 13D states concentrations of glycerin up to 50% and propylene glycol up to 40% are permitted

    ***Propylene glycol is not recommended for use with CPVC**
  - **Always verify chemical compatibility**
- Consult the local AHJ for requirements

BlazeMaster® FIRE PROTECTION SYSTEMS
V21.4

Propylene glycol is not recommended for use with CPVC

freezemaster. ANTIFREEZE

ANTIFREEZE SOLUTION REQUIREMENTS PER NFPA STANDARDS

STANDARD	SECTION	PROPYLENE GLYCOL	GLYCERIN
NFPA 13	*13.19, 8.6.2	Shall be listed for use in sprinkler systems	Shall be listed for use in sprinkler systems
NFPA 13D	13D.19, 9.2.2	Shall be listed for use in sprinkler systems or 38% with AHJ approval	Shall be listed for use in sprinkler systems or 48% with AHJ approval
NFPA 13R	*13R.19, 5.4.2	Follow NFPA 13: Shall be listed for use in sprinkler systems	Follow NFPA 13: Shall be listed for use in sprinkler systems
NFPA 25 All systems installed prior to 9/30/2012	25.17, 5.3.3.4	Before 9/30/2022 Listed antifreeze or: ▪ Pre-mixed non-listed 30% by volume ▪ Pre-mixed non-listed between 30-40% with a deterministic risk assessment and AHJ approval After 9/30/2022 ▪ Listed antifreeze	Before 9/30/2022 Listed antifreeze or: ▪ Pre-mixed non-listed 38% by volume ▪ Pre-mixed non-listed between 38-50% with a deterministic risk assessment and AHJ approval After 9/30/2022 ▪ Listed antifreeze
NFPA 25 All systems installed after 9/30/2012	25.17, 5.3.3.4.1	Shall be listed for use in sprinkler systems	Shall be listed for use in sprinkler systems

Note: New listed solutions are not required to be glycerin or glycol based as long as they pass UL 2901

*Effective since 2013 version

MAIN MENU Version: 21.4 EN

BlazeMaster®
FIRE PROTECTION SYSTEMS

V21.4

Specific Design Requirements

- Always refer to the Manufacturer's Installation Instructions
- Manufacturer's Installation Instructions are part of the UL listing and reviewed and approved
- These can be found on the manufacturer's websites

tyco Fire Protection Products

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(Canada Only)

MAIN MENU

Version: 21.4 EN

File Attachments for Item:

EC-15 FlowGuard Gold/Corzan Installation Training (Lubrizol Advanced Materials)

All certifications (2 hours)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Julie E. Schade

Organization: FlowGuard Gold/Corzan CPVC/Lubrizol Advanced Materials

Address: 9911 Brecksville Rd Brecksville, OH 44141

E-mail: julie.schade@lubrizol.com Telephone: 216-447-5677

Website: www.flowguardgold.com/www.corzan.com

Conference Sponsor (if applicable) — Conference Email: —

Check here if Course Renewal: — Prior course number — *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: FlowGuard Gold/Corzan Installation Training

Course instructor:

Course description: Installation Best Practices for installing FlowGuard Gold/Corzan CPVC piping systems, chemical compatibility

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: —

Special Content:

Code Administration: X
Existing Buildings: X
Electrical Instruction:
Plumbing Instruction: X

Conference Course: —
Conference Name: —
Conference location: —

Course to be offered online? NO **On Demand**____ **Webinar**____

Course Website:

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: Commercial Certifications:
Administrative Course, All Certifications:

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
NA Assessment Materials (for online courses) - in person training only
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

INSTRUCTOR NOTES:
FGG/CZ Installation Training Agenda

Topic	Time
Introduction	5 minutes
How to Identify	10 minutes
Advantages	10 minutes
Chemical Compatibility	15 minutes
Fire Performance	15 minutes
Product Installation	30 minutes
Questions	5 minutes

Training – 1 ½ hours

OHIO CEU Presenters Biographies –

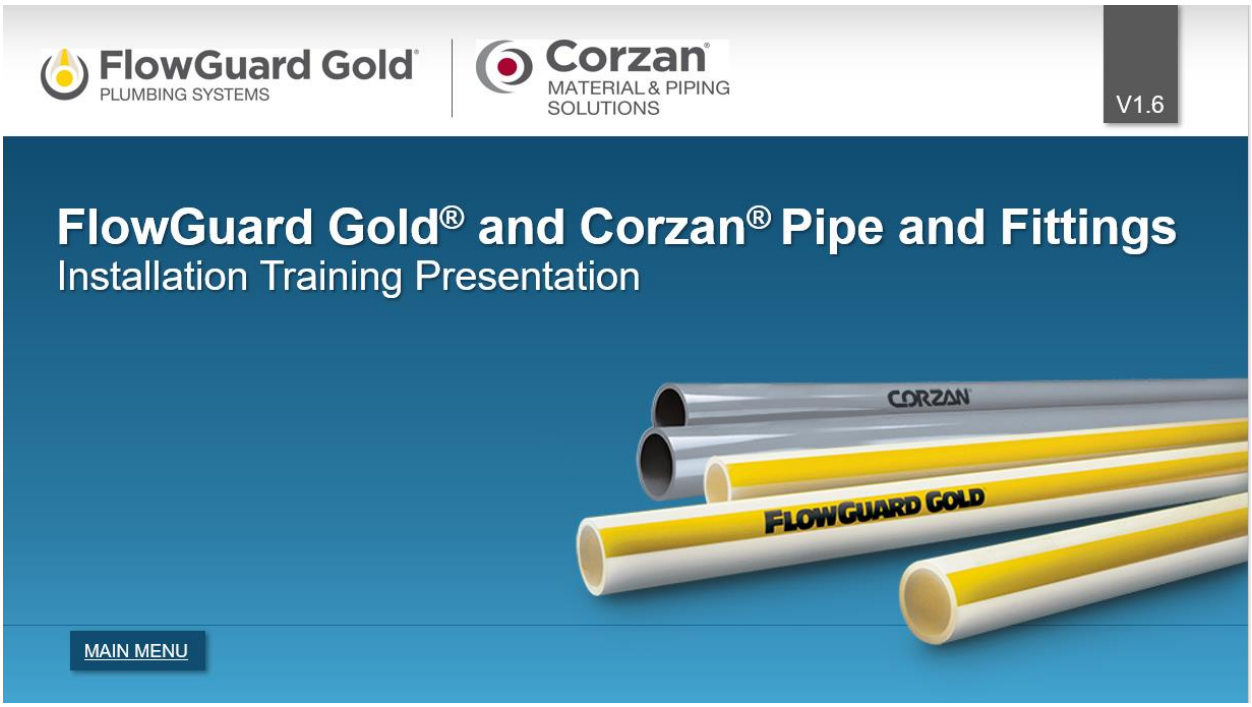
Joshua Horan
Joshua has enjoyed supporting the Thermoplastics industry for more than 15 years. His role with Lubrizol touches all aspects of the construction lifecycle, from specification to installation guidance for the brands FlowGuard Gold, Corzan, and BlazeMaster. He maintains a close connection with the engineering community through educational presentations, and the trades through on-site training and involvement with local trade schools as a guest instructor.

Lainey Liotta
Lainey is the Fire Protection Market Manager for LZAM's TempRite® business and is primarily responsible for setting the business strategy for BlazeMaster® Fire Sprinkler Systems and UL listed freezemaster™ antifreeze. A Penn State graduate with two degrees in Marketing and Spanish, Lainey started out her professional career at Tyco (now Johnson Controls.) Throughout her five years there, she held various product manager and commercial roles in their fire suppression business. After, she worked in business development for Chemours, focusing on driving forward the safe adoption of HFO refrigerants. She then joined Lubrizol in 2019, excited to get back into the fire protection industry. Lainey is a member of various NFSA, AFSA, and IFSA committees and is passionate about her role in advancing fire safety in buildings around the world.

Peter Mullen
Peter has more than 30 years of experience in sales, marketing and new business development in the plastic piping industry, with the last 25 specializing in CPVC with Lubrizol Advanced Materials (formerly Noveon and B.F. Goodrich). His experience covers plumbing, industrial, and fire protection applications, with additional experience in CPVC building products. Markets served include the residential and commercial plumbing & fire protection, chemical process, wastewater treatment, semiconductor, aerospace and metal treatment and refining. Global new business development assignments have also been completed while working with Lubrizol. Previous experience includes sales of other thermoplastic piping materials, including vinyl, polyolefins and fluoropolymers.

John Pritchard
John has been a piping systems consultant with Lubrizol for the past 12 years. John is a Chicago Licensed plumber and a member of Plumbers local # 130 over 35 years' experience in the plumbing/Mechanical Piping Industry. Bachelor of Science degree in Construction Management from Western Illinois University (1983). Member of the Western Illinois University Engineering Technology Advisory Council. Has worked as an instructor for the Residential Construction Employers Council (RCEC) Construction Management Certification Program (CMCP).

FlowGuard Gold / Corzan Installation Training – Print Screens



FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Who is Lubrizol?

- We are a specialty chemical company.
- 50+ years of CPVC innovation
- We manufacture the raw materials for the production of FlowGuard Gold, Corzan, and BlazeMaster CPVC pipe and fittings.
- Lubrizol supports their customers by providing training and education on CPVC piping systems.

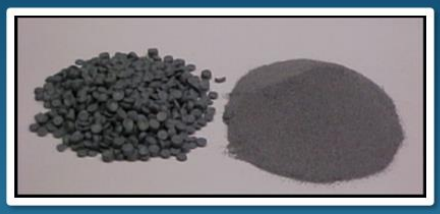
MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

What is CPVC?

- **Chlorinated Polyvinyl Chloride (CPVC):** A thermoplastic produced by chlorination of polyvinyl chloride (PVC) resin
- **Thermoplastic:** Polymer material that turns to liquid when heated and becomes solid when cooled.
- Lubrizol makes the powder and pellets that are extruded into pipe and injection molded into fittings for water distribution systems.
- Manufacturing partners make the pipe and fittings.



Pellets *for* Molding
Powder *for* Extrusion

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Availability

FlowGuard Gold pipe and fittings

- Copper Tube Size (CTS) – ½" – 2"

Corzan pipe and fittings

- Schedule 80 Iron Pipe Size (IPS)
- 1/2" – 24"

- A full line of solvent weld fittings, valves, and transitions

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Pipe and Fittings Manufacturers

FlowGuard Gold Pipe

BOW, Genova Products, Charlotte Pipe and Foundry Company, +GF+ Harvel, Cresline Plastic Pipe Co., Inc.

Fittings

BOW, Genova Products, Charlotte Pipe and Foundry Company, NIBCO AHEAD OF THE FLOW

Corzan Pipe

+GF+ Harvel, IPEX

Fittings

IPEX, NIBCO AHEAD OF THE FLOW

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

How To Identify

- NSF 61
- ASTM Standards
- How to Identify FGG
- How to Identify CZ

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Standards

- FlowGuard Gold Pipe and fittings are certified to meet ASTM D2846 requirements.
- Corzan pipe certified to meet ASTM F441 requirements
- Corzan Fittings certified to meet ASTM F437 and F439 requirements
  - (Sch 80 Threaded)
  - (Sch 80 Socket)
- NSF 61 Certified for potable water conveyance (no pH restriction)
- Copper is not NSF 61 certified for all water conditions. It may be susceptible to leaching contaminants when PH levels are high.

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Standards (continued)

- CTS SDR 11 pipe and fittings ½" – 2"
  - ASTM D2846 Specifies
    - Dimensions and tolerances for:
      - Pipe
      - Socket fittings
      - Transition fittings
    - Pressure bearing capability
      - 400 psi at 73.4°F
      - 100 psi at 180°F
    - Thermocycling for transition fittings – 1,000 cycles between 60°F and 80°F
    - Requirements for solvent cement joints
    - Constant ratio of wall thickness to outside diameter

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

How to Identify FlowGuard Gold Pipe and Fittings

Check for these markings on the Pipe:

- Manufacturer's Name
- NSF Mark (NSF-pw, CSA, etc.)
- Size
- ASTM D2846
- SDR 11
- 100 psi @ 180°F
- CPVC 4120
- ICC-ES PMG E84 25/50 Rated*

Check for these markings on the Fittings:

- Manufacturer's Name
- NSF Mark (NSF-pw, CSA, etc.)
- ASTM D2846
- CPVC 4120

*Not all FlowGuard Gold is listed and labeled. See manufacturer's installation instructions.

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

How to Identify Corzan Pipe and Fittings

Check for these markings on the Pipe:

- Manufacturer's Name
- NSF Mark (NSF-pw, CSA, etc.)
- Size
- ASTM F441
- Schedule 80
- Pressure rating at 73°F and 180°F
- CPVC 4120-05 or CPVC 4120-06

Check for these markings on the Fittings:

- Manufacturer's Name
- NSF Mark (NSF-pw, CSA, etc.)
- ASTM F441
- CPVC 4120

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Schedule 80 Pipe Pressure Rating

CTS SDR-11 is 400 psi at 73°F in all sizes

Sch. 80 IPS (in)	Maximum Water Pressure (psi) at 73°F
½"	850
2 ½"	420
3"	370
4"	320
6"	280
8"	250
10"	230

Consult pipe and fitting manufacturers for additional limitations

MAIN MENU

Pipe Pressure Rating

- With non-metallic systems the pressure rating of the pipe will decrease as the operating temperature increases.
- To obtain the pressure rating above 73°F, multiply the pressure rating at 73°F by the appropriate derating factor.

Working Temperature (°F)	Pipe De-rating Factor
73 – 80	1.00
90	0.91
100	0.82
120	0.65
140	0.50
160	0.40
180	0.25
200	0.20

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS
V1.6

Pressure Rating Calculation

Pressure Rating at Temperature X =

- Pressure Rating at 73°F multiplied by Derating Factor at Temperature X

Example

Calculate the pressure rating of a 3" Schedule 80 pipe at 140°F

Pressure Rating at 73°F = 370 psi

Derating Factor at 140°F = 0.50

Temperature Rating at 140°F = 370 psi X 0.50

= 185 psi

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Advantages of FlowGuard Gold and Corzan Pipe and Fittings

- Durability
- Heat Resistance
- Corrosion Resistance

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Advantages of FlowGuard Gold and Corzan Pipe and Fittings

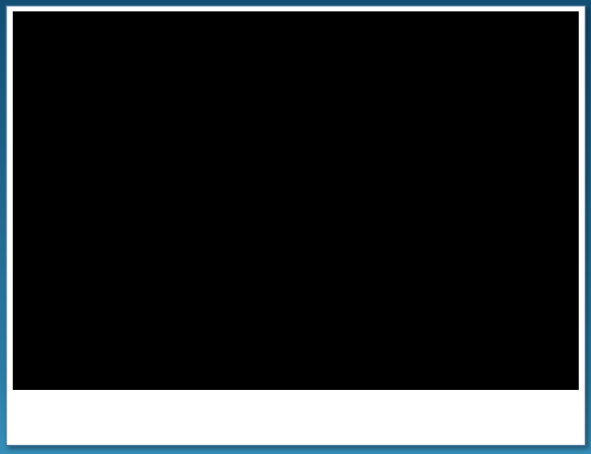
- Durability
- Heat Resistance
- Corrosion Resistance

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Drop Impact Video



MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Durability

Higher Impact Strength

- Three times the impact strength of standard CPVC
- Pipe can be cut easier
- Fewer breaks and fractures
- Lower scrap rate

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Improved Properties

Higher Heat Distortion Temperature

- Minimum HDT of 230°F for FlowGuard Gold and Corzan CPVC - vs- 212°F for standard CPVC
- FlowGuard Gold and Corzan pipe will keep its straight, professional appearance where standard CPVC may sag or bend.

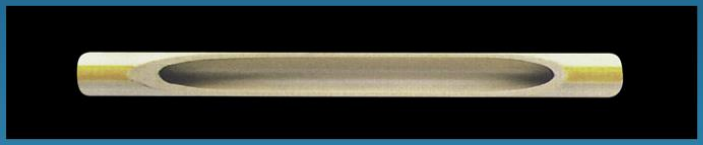
MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Resists Corrosion and Scaling

The Hazen-William C Factor for copper decreases over time.



The Hazen-William C Factor for FlowGuard Gold pipe remains constant over the life of the system.

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Quick Burst Video

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Chemical Compatibility

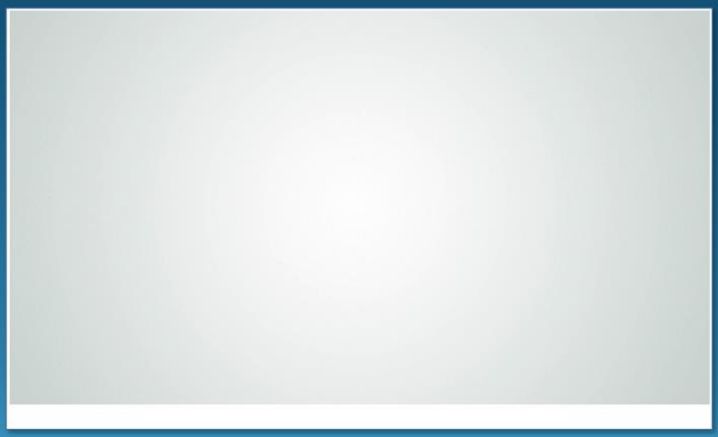
- Introduction to Chemical Compatibility
- FBC™ System Compatible Program
- Chemical Compatibility Tips

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

The Benefits of the FBC System Compatible Program Video



MAIN MENU

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Chemical Compatibility

FBC SYSTEM COMPATIBLE

- CPVC can be damaged by contact with chemicals found in some construction products such as:
  - Edible oils
  - Petroleum – or solvent-based sealants
  - Lubricants or firestop materials
  - Glycol-based antifreeze
  - Reference www.fbcsystemcompatible.com for complete list
  - The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

FBC™ System Compatible Program

- The FBC™ System Compatible Program is designed to test the chemical compatibility of ancillary products with BlazeMaster pipe & fittings
  - Look for the "FBC System Compatible" logo on ancillary product labels or packaging

- Actively used around the world
- Only applicable to the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Chemical Compatibility

- Download the new FBC System Compatible product finder from the app store (search Lubrizol CPVC)
- Our "Understanding Chemical Compatibility" videos give a more in-depth understanding of chemical compatibility. They can be found on the System Compatible website

MAIN MENU

The FBC™ System Compatible Program is only applicable to the chemical compatibility of ancillary products with the brands of FlowGuard, BlazeMaster, and Corzan piping systems and products made with TempRite Technology.

The absence of a produce from the incompatible list does not insure compatibility with Lubrizol's CPVC.

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Fire Performance

- Combustibility
- Penetrating Fire Rated Walls, Floors and Ceilings

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Combustibility

- The ignition temperature is the lowest temperature at which sufficient combustion gas is evolved that can be ignited by a small flame
- CPVC has a flash ignition temperature of 900°F
- Common construction materials, such as wood, have a flash ignition temperature of 500° or less
- CPVC will not sustain burning
- The LOI (limited oxygen index) is the percentage of oxygen needed to support combustion
  CPVC has an LOI of 60
- The smoke from CPVC is no more toxic than the smoke from wood

MAIN MENU

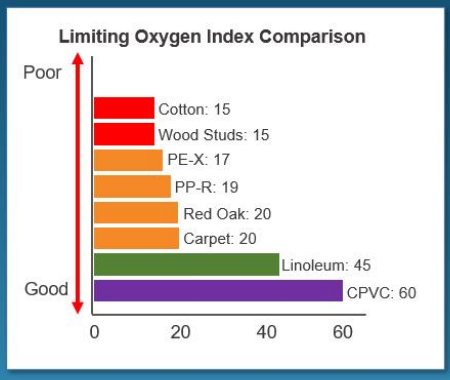
FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

CPVC and Combustion

- Limited Oxygen Index (LOI) – the percentage of oxygen needed in the atmosphere to support the combustion of a material
- CPVC requires more oxygen to sustain a flame than what is available in the atmosphere
- The oxygen level in the Earth's atmosphere is not more than 21%
- Once the flame source is removed, the FGG pipe self-extinguishes

Therefore, CPVC does not sustain a flame



MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Flame Test Video

MAIN MENU

Note: There is not any smoke. The flame does not travel. As soon as the flame goes out, the fire is out.

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V1.6

Corzan and FlowGuard Gold CPVC Pipe and Fittings Listed For Use In Plenums Service

In most commercial buildings, the area above the suspended ceiling is used as an air plenum. Model codes restrict the surface burning characteristics of the materials that can be installed in air plenums

Various tests are used to evaluate the surface burning characteristics of constructions materials. The most common requirement is to restrict materials permitted within plenums to those meeting a 25/50 flame spread/smoke developed when tested in accordance with ASTM E84. As a reference, asbestos cement has a 0/0 flame spread/smoke developed rating and red oak has a 100/100 flame spread/smoke developed rating

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Corzan and FlowGuard Gold pipe and fittings have been listed by ICC-ES under PMG-1264 and IAPMO UES under UEL-5002. The following models have been tested water-filled or dry as a modified version of UL 723/ASTM E84 test methods for surface burning characteristics and have been found to meet the 25/50 flame spread/smoke developed requirements of the International Mechanical Code® (IMC) and the Uniform Mechanical Code® (UMC) for installation in ducts and plenums

- 1/2" – 2" water-filled FlowGuard Gold* CPVC pipe and fittings have a flame spread index of no more than 5 and a smoke developed index of no more than 35
- 1/2" – 2" dry FlowGuard Gold CPVC* pipe and fittings for condensate lines have a flame spread index of no more than 5 and a smoke developed index of no more than 25
- 1/2" – 6" water-filled Corzan CPVC pipe and fittings have a flame spread index of 0 and a smoke developed index of no more than 20

*Not all FlowGuard Gold is listed and labeled. See manufacturer's installation instructions

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Penetrating Fire Rated Walls, Floors, and Ceilings

- Building codes require that fire rated walls be returned to their original fire rating when penetrated by pipes, ducts, wires, etc
- Penetrations through fire rated walls, floors, and ceilings must be protected with an approved firestop system
- Several firestop systems are Listed for use with CPVC
- Manufacturers of firestop materials or systems are responsible for maintaining listings of their systems
- Verify the firestop is chemically compatible with FlowGuard Gold and Corzan Pipe and Fittings prior to use

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

ICC EVALUATION SERVICE

Most Widely Accepted and Trusted

ICC-ES PMG Listing PMG-1264

Effective Date: June 2014
Revised Date: July 23, 2014
This listing is subject to re-examination in one year.

www.icc-es-pmg.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

CSI: DIVISION: 23 00 00—MECHANICAL
Section: 23 00 00—HVAC

Product certification system:

The ICC-ES product certification system includes testing samples taken from the market or supplier's stock, or a combination of both, to verify compliance with applicable codes and standards. The system also involves factory inspections, and assessment and surveillance of the supplier's quality system.

Product: Surface Burning Characteristics for FlowGuard Gold® and Corzan® CPVC Pipe and Fittings

Listee: Lubrizol Advanced Materials, Inc.
9911 Brecksville Road
Cleveland, Ohio 44141
www.lubrizol.com/cpvc

Additional Companies:

Bow Industrial Corporation (FlowGuard Gold® Pipe and Fittings)
15 Vittle Street
Granby, QC J2G 6N8
Canada
www.bow-group.com

Cresline Plastic Pipe Co., Inc. (FlowGuard Gold® Pipe)
600 Cross Pointe Boulevard
Evansville, IN 47715
www.cresline.com

Genova Products, Inc. (FlowGuard Gold® Pipe and Fittings)
P.O. Box 309
Davison, MI 48423
www.genovaproducts.com

Georg Fischer Harvel LLC (FlowGuard Gold® Pipe and Corzan® Pipe)
300 Kuebler Road
Easton, PA 18040
www.harvel.com

IPEX USA LLC (Corzan® Pipe and Fittings)
2441 Royal Windsor Drive
Mississauga, On L5J 4C7
Canada
www.ipexamerica.com

NIBCO Inc.(FlowGuard Gold® fittings and Corzan® fittings)
1516 Middlebury Street
Elkhart, Indiana 46516
www.nibco.com

Listings are not to be construed as representing aesthetics or any other attributes not specifically addressed, nor are they to be construed as an endorsement of the subject of the listing or a recommendation for its use. There is no warranty by ICC Evaluation Service, LLC, express or implied, as to any finding or other matter in this listing, or as to any product covered by the listing.

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Listee:

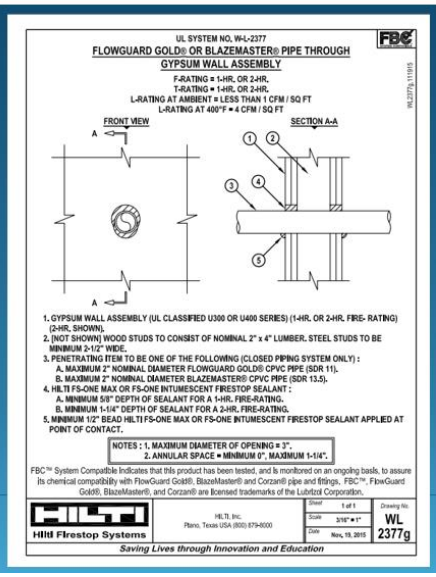
- Lubrizol Advanced Materials, Inc.

Additional Companies:

- Bow Industrial Corporation (FlowGuard Gold® Pipe and Fittings)
- Cresline Plastic Pipe Co., Inc. (FlowGuard Gold® Pipe)
- Genova Products, Inc. (FlowGuard Gold® Pipe and Fittings)
- Georg Fischer Harvel LLC (FlowGuard Gold® Pipe and Corzan® Pipe)
- IPEX USA LLC (Corzan® Pipe and Fittings)
- NIBCO Inc. (FlowGuard Gold® Fittings and Corzan® Fittings)

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6



UL SYSTEM NO. W-L-2377

FLOWGUARD GOLD® OR BLAZEMASTER® PIPE THROUGH GYPSUM WALL ASSEMBLY

F-RATING = 1-HR, OR 2-HR.
T-RATING = 1-HR, OR 2-HR.
L-RATING AT AMBIENT = LESS THAN 1 CFM / SQ FT
L-RATING AT 400°F = 4 CFM / SQ FT

FRONT VIEW

SECTION A-A

1. GYPSUM WALL ASSEMBLY (UL CLASSIFIED U300 OR U400 SERIES) (1-HR. OR 2-HR. FIRE- RATING) (2-HR. SHOWN).
2. [NOT SHOWN] WOOD STUDS TO CONSIST OF NOMINAL 2" x 4" LUMBER. STEEL STUDS TO BE MINIMUM 2-1/2" WIDE.
3. PENETRATING ITEM TO BE ONE OF THE FOLLOWING (CLOSED PIPING SYSTEM ONLY) :
   A. MAXIMUM 2" NOMINAL DIAMETER FLOWGUARD GOLD® CPVC PIPE (SDR 11).
   B. MAXIMUM 2" NOMINAL DIAMETER BLAZEMASTER® CPVC PIPE (SDR 13.5).
4. HILTI FS-ONE MAX OR FS-ONE INTUMESCENT FIRESTOP SEALANT :
   A. MINIMUM 5/8" DEPTH OF SEALANT FOR A 1-HR. FIRE-RATING.
   B. MINIMUM 1-1/4" DEPTH OF SEALANT FOR A 2-HR. FIRE-RATING.
5. MINIMUM 1/2" BEAD HILTI FS-ONE MAX OR FS-ONE INTUMESCENT FIRESTOP SEALANT APPLIED AT POINT OF CONTACT.

NOTES : 1. MAXIMUM DIAMETER OF OPENING = 3".
2. ANNULAR SPACE = MINIMUM 0", MAXIMUM 1-1/4".

FBC™ System Compatible indicates that this product has been tested, and is monitored on an ongoing basis, to assure its chemical compatibility with FlowGuard Gold®, BlazeMaster® and Corzan® pipe and fittings. FBC™, FlowGuard Gold®, BlazeMaster®, and Corzan® are licensed trademarks of the Lubrizol Corporation.

HILTI Hilti Firestop Systems

HILTI, Inc. Plano, Texas USA (800) 879-8000

Sheet 1 of 1 | Scale 3/16" = 1" | Date Nov. 19, 2015 | Drawing No. WL 2377g

Saving Lives through Innovation and Education

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Product Installation

- Health and Safety
- Handling and Storage
- Solvent Cement Joining
- Installing FlowGuard Gold Pipe and Fittings
- Installing Corzan Pipe and Fittings
- Pressure Testing
- Transition Joints & Fittings
- Hangers & Supports
- Thermal Expansion & Contraction

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Health and Safety

- Provide ventilation or NIOSH approved respirator if necessary
- Wear proper protective clothing including gloves and safety goggles while solvent welding
- Refer to ASTM F402 for additional recommendations

MAIN MENU

Presentation last modified: Yesterday at 4:29 PM

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Pipe and Fittings Handling and Storage

- UV exposure may cause discoloration and reduced impact strength
  - Pressure rating is not affected
  - Avoid prolonged direct sunlight exposure
- Do not store unprotected outside
- Cover with a non-transparent material to protect from UV exposure
  - Manufacturer packaging provides UV protection
  - Compatible insulation or water-based paint
- FlowGuard Gold and Corzan Pipe and fittings should not be dropped, stepped on, dragged or thrown
- Always inspect for splits, cuts and gouges prior to installation
- Keep pipe and fittings in original packaging until needed
- Avoid contamination with petroleum-based products such as cutting or packing oils

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Solvent Cement & Primer Storage and Handling

- Store between 40°F - 110°F or as specified on the label
- Do not store near heat, sparks, open flames or other sources of ignition
- Keep containers tightly closed when not in use
- Keep containers as covered as possible when in use

MAIN MENU

FlowGuard Gold PLUMBING SYSTEMS | Corzan MATERIAL & PIPING SOLUTIONS

V1.6

Solvent Cement Welding System

- One step solvent cement for use with FlowGuard Gold pipe and fittings
  - ASTM F493
  - NSF mark (NSF-pw, etc.)
  - Manufacturer's name and address
- Used with CTS pipe and fittings
- Yellow in color
- **Does not** require the use of primer

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V1.6

Two-Step Solvent Welding Process for Use with Corzan Schedule 80 Plumbing Systems

- ASTM F493
- Orange Color

Primer Requirements

- ASTM F656
- Purple or clear
- Check local code requirements

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The code requires orange cement; however gray cement is allowed in some municipalities. Check with code official.

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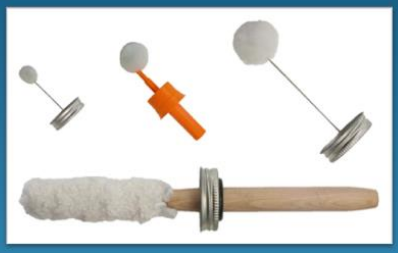
V1.6

Proper size applicators are important

- Use a dauber that is properly sized for the pipe
  - Approximately ½ the size of the pipe internal diameter
- Proper dauber size is very important to prevent puddling and obtain proper coverage



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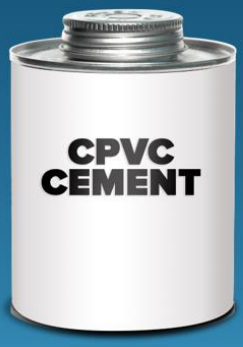
Cure Times

Refer to the time required after solvent welding before pressure testing the system

Cure times are a function of:

- Pipe size and length
- Solvent cement used
- Temperature
- Humidity
- Degree of interference

Refer to manufacturer's recommended set and cure times



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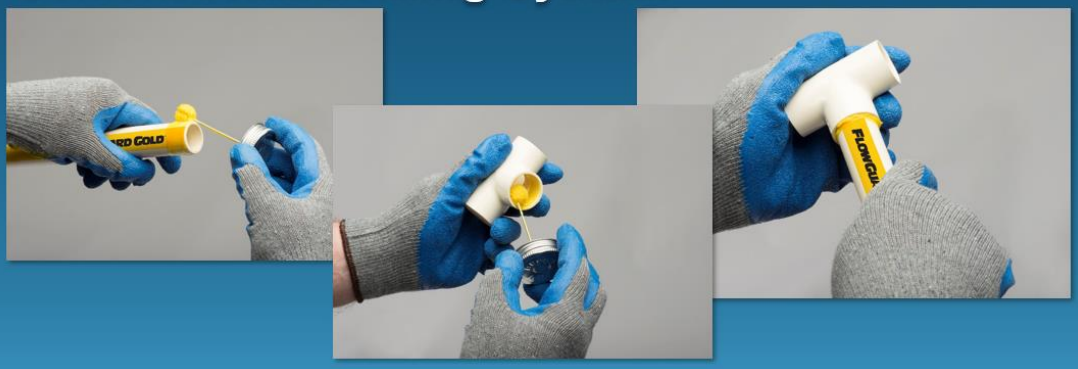
Solvent Weld Joining System



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Solvent Weld Joining System

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Turn ¼ turn before cement dries.

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FlowGuard Gold Cut & Join

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V1.6

Corzan Cut & Join

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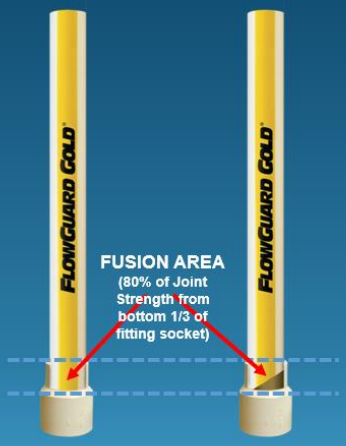
V1.6

Interference Fit Fittings

- **ALWAYS** cut pipe straight
- **ALWAYS** push the pipe the entire way in to the fitting
- **ALWAYS** hold for the entire recommended "set time"
- **WHEN POSSIBLE,** perform a quarter-turn when pipe is inserted on small sizes



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Pressure Testing

- The system should not be pressure tested until minimum cure times have been met
- Fill the system with water and bleed air from the highest point
- Pressure test in accordance with local code requirements
- Repair any leaks and retest

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V1.6

Avoid Dry Fits!

- Align print line while installing pipe
- Walk the job afterwards to check for dry fits

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Transition to Other Materials

- Several types of transition fittings are available:
  - CPVC insert
  - Threaded
  - Grooved
  - Flanged
- Follow manufacturer's recommendations for temperature and pressure limitations on threaded adapters
- Additional support should be added to the metal side of the transition fitting

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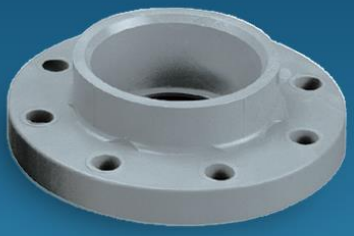
Corzan Flanged Connections

- Corzan flanged connections are rated for 150 psi max.
- Use full face gaskets which are chemically compatible
- Use washers on all nuts and bolts
- Follow manufacturer's torque requirements
- High-pressure flange kits are available in 2" – 6" to bring a flanged connection to the full rating of the pipe



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Valves for Use with CPVC

- A variety of valves are available for use with CPVC
- Use CPVC or metal valves
- Various connection methods are available:
  - Solvent cement
  - Threaded
  - Flanged
- Make sure that hangers are in place to support the weight of the valve

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Vertical Piping (Risers) Supports

- Use hangers and straps that do not distort, cut or abrade the pipe
- Use hangers that can support the weight of the water-filled pipe
- Maintain straight alignment with supports at each floor plus a mid-story guide

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Horizontal Piping Supports

- Piping should not be anchored tightly to supports
  - Allow for movement due to expansion and contraction
  - Prevents noise
- Use smooth straps or hangers that will not damage the pipe
- No rough or sharp edges should come in contact with the pipe
- When going through metal studs, the pipe must be protected
- Concentrated loads, such as valves, must be separately supported

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Metal hangers are preferred. Plastic-coated straps or hangers may contain incompatible plasticizers.

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Hanger Spacing

- Verify hanger spacing with local code official prior to installation
- Code officials vary in their hanger spacing requirements

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FlowGuard Gold Hanger Support Spacing

Copper Tube Size (CTS) Support Spacing, Feet				
Nominal Pipe Size (in)	Maximum Water Temperature			
	73°F	100°F	140°F	180°F
½"	4	4	3 ½	3
¾"	5	4 ½	4	3
1"	5 ½	5	4 ½	3
1 ¼"	6	5 ½	5	4
1 ½"	6 ½	6	5 ½	4
2"	7 ½	7	6 ½	4

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Corzan Hanger Support Spacing

Iron Pipe Size (IPS) Support Spacing, Feet				
Nominal Pipe Size (in)	Maximum Water Temperature			
	73°F	100°F	140°F	180°F
½"	5 ½	5	4 ½	2 ½
¾"	5 ½	5 ½	4 ½	2 ½
1"	6	6	5	3
1 ¼"	6 ½	6	5 ½	3
1 ½"	7	6 ½	5 ½	3 ½
2"	7	7	6	3 ½
2 ½"	8	7 ½	6 ½	4
3"	8	8	7	4
4"	9	9	7 ½	4 ½
6"	10	9 ½	8	5
8"	11	10 ½	9	5 ½
10"	11 ½	11	9 ½	6

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Supporting Metal Studs

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Freeze Protection

- Model plumbing codes require that the piping exposed to freezing temperatures be properly protected
  - Eliminate the source of air causing the freeze condition
  - Locate the frozen section and thaw the water line, if possible
  - Close any outside openings with insulation, circulate warm air into the area or direct heated air onto the piping using a low wattage heater/blower
  - Once ice plug has melted, check to see if any pipe or fitting is ruptured, make repairs if necessary, and insulate the area or pipe to prevent future freezing
- Do not use an open flame to heat the frozen pipe!

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From PPFA Guide (pg. 14)

Avoid Compressive Stress

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Thermal Expansion and Contraction

- All piping materials expand and contract with temperature change
- CPVC will expand about 1" per 50' of length when subjected to a 50°F temperature increase
- Expansion does not vary with pipe size
- Expansion is mainly a concern on hot water lines
- Stresses are less than with metal systems and in most cases are accommodated with a change in direction
- Expansion loop requirements are smaller than those recommended for copper
- When properly sized, only one loop is required

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Thermal Expansion and Contraction

- Generally, expansion can be accommodated with changes in direction
- An offset or loop may be required on a long, straight run
- One properly sized expansion loop is all that is required in any single, straight run
- Two or more smaller expansion loops, properly sized, can be utilized in a single, straight run of pipe
- Hang pipe with smooth straps that will not restrict movement
- Do not butt-up against fixed structure (joist, stud, wall)

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Expansion Loop Calculation

EXPANSION LOOP FORMULA: $\mathscr{L} = \sqrt{\frac{3\,E\mathscr{L}D\,(\triangle L)}{2S}}$

Where: $\mathscr{L}$ = Loop length (in.)
$E\mathscr{L}$ = Modulus of elasticity at maximum temperature (psi)
S = Working Stress at maximum temperature (psi)
D = Outside diameter of pipe (in.)
$\triangle L$ = Change in length due to change in temperature (in.)
(See formula below)

THERMAL EXPANSION FORMULA: $\triangle L = L_D C \triangle T$

Where: $\triangle L$ = Change in length due to change in temperature (in.)
L_D = Length of pipe (in.)
C = Coefficient of thermal expansion (in./in./°F)
= 3.4×10^{-5} in./in./°F for CPVC
$\triangle T$ = Change in temperature (°F)

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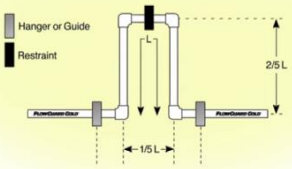
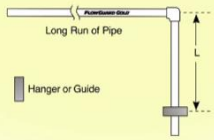
Expansion and Contraction

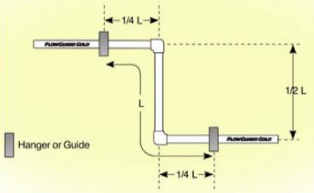
Loop - Do not butt up against fixed structure (joist, stud, or wall)



Change of Direction - Expansion loop and offset configuration



Offset - Do not butt up against fixed structure (joist, stud, or wall)



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Click on each image for animation.

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Loop Length

FGG Pipe SDR 11 (ASTM D 2846) Length of Run in Feet

Nominal Pipe Size (in)	40	60	80	100
	Loop Length "L" in Inches			
½"	23	28	33	37
¾"	28	34	39	43
1"	31	38	44	49
1 ¼"	34	42	49	54
1 ½"	37	46	53	59
2"	43	52	61	68

Corzan Pipe Schedule 80 (ASTM F 441) Length of Run in Feet

Nominal Pipe Size (in)	40	60	80	100
	Loop Length "L" in Inches			
½"	27	33	38	43
¾"	30	37	43	48
1"	34	41	48	53
1 ¼"	38	46	54	60
1 ½"	41	50	57	64
2"	45	55	64	72
2 ½"	50	61	70	79

Corzan Pipe Schedule 80 (ASTM F 441) Length of Run in Feet

Nominal Pipe Size (in)	40	60	80	100
	Loop Length "L" in Inches			
3"	55	67	78	87
3 ½"	59	72	83	93
4"	62	76	88	99
5"	69	85	98	110
6"	76	93	107	120
8"	86	106	122	136

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V1.6

Nested Expansion Loops

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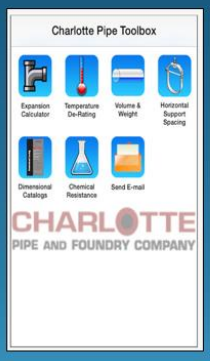
Digital Tools to Help You

Charlotte Pipe app



Plastic Pipe Institute

PLASTICS PIPE INSTITUTE

http://www.plasticpipe.org/building-construction/bc-plastic-pressure-pipe-design-calculator.html

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V1.6

Questions?

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File Attachments for Item:

EC-16 Updating Ohio's Codes for 2024 Round Table (Molnar)

All certifications (1 hour)

1 hour Code Administration

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:

Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:

Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: David Molnar

Organization: _____

Address: 4201 Copley Road, Copley, Ohio 44321

E-mail: dmolnar1@hotmail.com Telephone: (330) 714-0982

Website: _____

Conference Sponsor (if applicable) _____ Conference Email: _____

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Updating Ohio's Codes for 2024, A Roundtable Presentation of the Who, What, When, How and Why

Course instructor: David Molnar

Course description: A compact overview of the proposed updates to the Ohio Building Code, Ohio Mechanical Code, Ohio Plumbing Code and the Residential Code of Ohio We will help attendees: Understand the reasoning for the adoption of the new codes; Discuss proposed changes and what these mean for their profession; Describe the process of the Code changes and the plan review process; Identify how their voice can be and is heard in this process; Find additional information, contacts and milestones for this process.

Instructional hours per session: 1 Number of Sessions: _____

Course Date(s) and Location: _____

Special Content:

Code Administration: ☑
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☑

Commercial Certifications: ☑

Application materials included:

☑ Course Outline or Course Learning Objectives
☐ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

Updating Ohio's Codes for 2024,

A Roundtable Presentation of the Who, What, When, How and Why

- WHY
  - Help to create a better end product to serve the purpose of the Code.
  - Being part of the process helps in understanding "why they are that way".
  - 101.3 Intent. The purpose of this code is to establish Uniform Minimum Requirements.
- WHO
  - Everyone in the State of Ohio who is involved in the built environment - Owners, Architects, Engineers, Builders, Finance and Insurance Professionals, Material Suppliers and everyone else who enters a building.
- WHAT
  - Ohio Building Code
  - Ohio Mechanical Code
  - Ohio Plumbing Code
  - Residential Code of Ohio
  - Reference Standards
    - ICC A 117.1
    - NFPA 13
    - NFPA 70
    - NFPA 72
    - IECC
    - IEBC
    - IFGC
    - IFC*
- WHEN
  - Target date is January 1, 2024
  - During March 2023, the Board will solicit initial stakeholder feedback through written comments and at the stakeholder meeting on March 22. Comments received will be reviewed by the Board's Code Committee and the Residential Construction Advisory Committee. After review of initial comments, the Board will incorporate any approved changes and document the reasons for the changes in a Business Regulatory Impact Analysis (BIA).

    The revised rules and the BIA will then be filed with the CSI Office for review and recommendation and resent to stakeholders via eNotification. After receipt of the CSI Office recommendations and any additional stakeholder comments, the Board will determine whether to move forward with formal rule-filing.

    If the Board does determine to formally file these rules, as revised, with the Joint Committee on Agency Rule Review (JCARR), the Board will also conduct a public hearing currently to a date to be determined prior to their adoption.
  - Notable Milestones:
    - eNotification and Common Sense Initiative (CSI) Office Review
    - Public Hearings
    -

- HOW
    - Model Codes - ICC follows a three-year cycle to review changes and vote to incorporate.
        - Current 2017 OBC based on 2015 IBC with some 2108 IBC updates.
        - Proposed 2024 OBC is based on 2021 IBC
    - Reference Standards – updated on various cycles from yearly to multiple year cycles based on advancements in industry
    - Stake Holders Meetings
    - Submit written comments on the proposed rules to BBS@com.ohio.gov.
    - Talk with your local Building Officials (Building Officials, Plans Examiners and Inspectors).
    - Join or attend Building Official chapter meetings.

BBS Resources, Commentaries, Guides and Handouts:

- Application to Change the Building Code
- Proposed 2024 Ohio Building Code Rules
- Proposed 2024 Ohio Mechanical Code Rules
- Proposed 2024 Ohio Plumbing Code Rules
- 2024 OBC Rule Change Summary
- 2024 OMC Rule Change Summary
- 2024 OPC Rule Change Summary
- Proposed 2019 Residential Code of Ohio Amendments
- RCO Amendments Summary

David Molnar:

Mr. Molnar is the Master Plans Examiner for Richland County and serves as the part-time Chief Building Official for the City of Aurora as well as an Intermittent Plans Examiner for the Ohio Division of Industrial Compliance. He was previously the Chief Building Official for the Medina County Building Department and the City of Canton where he was in charge of the Building Department overseeing the Zoning, Code Enforcement and Building Inspection. Mr. Molnar holds a Bachelor of Architecture from Kent State University and is a licensed Architect in the State of Ohio. He is a member of the International Code Council (ICC), is the current Treasurer and has served as a Director for the Ohio Building Officials Association (OBOA) and served as the President for the Five County Building Officials Association (FBOA) from 2018 through 2022. David holds certificates from the Ohio Board of Building Standards and the ICC for Master Plans Examiner, Building Official and Residential Building Official as well as certifications from FEMA for Disaster response.