

TORNADO SAFE ROOM

250 mph safe room design wind speed (3-second gust)
Missile Impact Resistance:
15 lbs. 2x4 @ 67 mph (horizontal)
15 lbs. 2x4 @ 100 mph (vertical)
Safe room manufacturer/builder



HURRICANE SAFE ROOM
180 MPH SAFE ROOM DESIGN AND WIND SPEED (3-SEC GUST)
MISSILE IMPACT RESISTANCE
160 PSF/UPLIFT 126 PSF (ULTIMATE) (HORIZONTAL SURFACES)
9LB. 2X4 @ 90 MPH (VERTICAL SURFACES)
BUILDER:

Highlights of ANSI/ ICC 500-2023

ICC/NSSA Standard for the Design and Construction of Storm Shelters

November 2024



FEMA

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Acronyms and Abbreviations

ACI	American Concrete Institute
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
IBC	International Building Code
ICC	International Code Council
IEBC	International Existing Building Code
IPS	impact-protective systems
IRC	International Residential Code
mph	miles per hour
NFPA	National Fire Protection Association
NSSA	National Storm Shelter Association
PBD	performance-based design
SEI	Structural Engineering Institute

1. Introduction

Published by the International Code Council® (ICC®) and the National Storm Shelter Association (NSSA®), the *ICC/NSSA Standard for the Design and Construction of Storm Shelters* (ICC 500),¹ is a referenced standard in the International Codes (I-Codes). The ICC, in partnership with the NSSA, formed a national committee in 2003 that developed and released a consensus standard to codify the design and construction requirements of tornado and hurricane storm shelters. ICC 500 was first published in the summer of 2008 and updated in December of 2014, 2020, and 2023. ICC 500 provides:

the minimum requirements to safeguard the public health, safety and general welfare relative to the design, construction and installation of storm shelters constructed for protection from tornadoes, hurricanes and other severe windstorms. This standard is intended for adoption by government agencies and organizations for use in conjunction with applicable codes to achieve uniformity in the technical design and construction of storm shelters (ICC 500 Section 101.1).

ICC 500 applies to the design, construction, installation, and inspection of community and residential storm shelters. **Residential** storm shelters serve occupants of dwelling units and have an occupant capacity not exceeding 16 people. **Community** storm shelters are storm shelters that are not residential storm shelters; they may include shelters intended for use by the general public, by occupants of a specific campus or building, or a combination of both. Storm shelters are permitted to be either separate, detached buildings, or enclosed or partially enclosed within a host building.

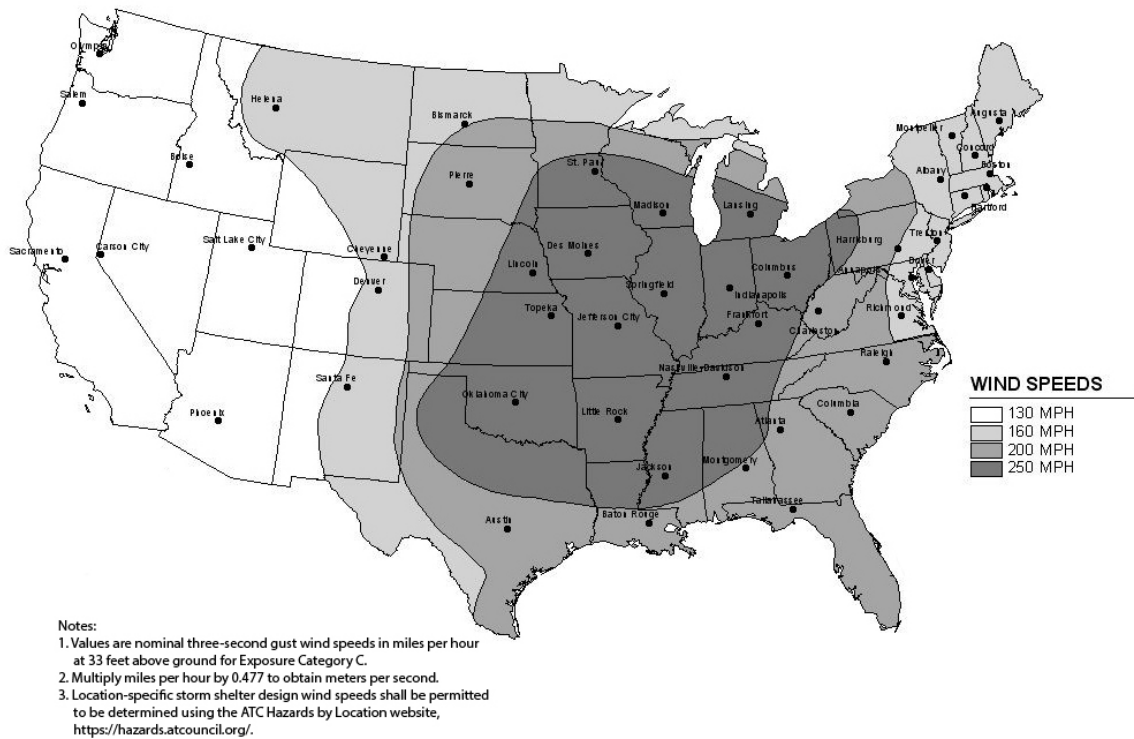
Since the 2009 editions of the ICC's *International Residential Code* (IRC) and *International Building Code* (IBC), ICC 500 has been referenced as the governing standard for the design and construction of storm shelters. Additionally, Section 423 of the 2015, 2018, 2021, and 2024 editions of the IBC requires new buildings with certain uses or occupancies and geographic locations to be built with a storm shelter. Based on Section 423, the following structures must include a storm shelter constructed in accordance with ICC 500 when located in a 250-mile-per-hour (mph) wind speed zone for tornadoes per Figure 304.2 of ICC 500 (refer to Figure 1):

- 911 call stations
- Emergency operations centers
- Fire, rescue, and ambulance stations

¹ ICC 500 is an American National Standard approved by the American National Standards Institute (ANSI). The current edition is formally titled 2023 ANSI/ICC 500, *ICC/NSSA Standard for the Design and Construction of Storm Shelters*, but is referred to in this document as ICC 500.

- Police stations
- K-12 school buildings with an occupant load of 50 or more, with certain exceptions

Further, the 2018, 2021, and 2024 editions of the International Existing Building Code (IEBC) provide storm shelter requirements for additions to existing buildings that parallel the storm shelter requirements for new buildings in IBC Section 423.



SOURCE: ICC 500 (2023) FIGURE 304.2; USED WITH PERMISSION

Figure 1: Design tornado speeds for tornado storm shelters

2. Highlights of the 2023 Edition of ICC 500

ICC 500 sets forth requirements for a range of topics related to the design and construction of storm shelters, including administration; structural design and testing; siting; occupant density, entry, accessibility, egress, and signage; fire safety; essential features and accessories; and test methods for impact and pressure testing. Highlights of ICC 500 (2023 edition) are described in the sections that follow.

2.1. Application and Administration

- The standard establishes basic requirements that govern its application, including scope, referenced standards, compliance alternatives, conventions (e.g., dimensions and use of figures), construction and occupancy, and applicable codes.
- ICC 500 specifies the information required on submittal documents, which must be prepared and sealed by a registered design professional with every permit application. The standard also includes provisions for quality assurance plans, contractor responsibilities, peer review, special inspection, and structural observations.
- Owner responsibility requirements for new shelters include submission of operation plans and the ongoing evaluation, maintenance, and repair of existing shelters.

2.2. Structural Design and Testing Criteria

- The standard requires testing where the capacity of the storm shelter envelope cannot be determined by engineering calculations.
- Storm shelter design loads and load combinations are required to be in accordance with the applicable code, as modified by ICC 500. The modified load combinations for storm shelters must be applied in addition to “normal use” load combinations in the applicable code.
- The standard provides modifications to wind-load parameters and tornado-load parameters that are required to design hurricane storm shelters and tornado storm shelters, respectively. Aside from wind and tornado loads, ICC 500 modifies storm shelter requirements for rain loads, floor live loads, roof live loads, hydrostatic loads, and flood loads.
- The standard provides requirements for shielding of shelters from host and adjacent buildings and for the connections between a storm shelter and its host building. Storm shelter designers are not permitted to lessen wind loads or wind-borne debris impacts that may result from shielding by the host or adjacent buildings, because the host or adjacent buildings may fail. Further, the storm shelter must be able to resist the maximum forces that could be transmitted through connections between the host building and the shelter.
- ICC 500 addresses resistance to wind-borne debris hazards through missile impact testing requirements. Representative test missile sizes are a function of the shelter’s designated storm type, whereas test missile speeds vary with storm type, shelter design wind speed or tornado speed, and orientation (vertical or horizontal) of the shelter assembly or component.
- ICC 500 requires storm shelters to be designed to resist the impact loads from potential laydown and falling debris hazards by defining site conditions that trigger application of design impact loads and quantifying the minimum impact loading. It also requires impact loads from these hazards to be considered one at a time additively with the uniform roof live load.

- The standard provides storm shelter envelope component design and testing requirements with references to Chapter 8 for the corresponding impact and pressure test methods.
- Listing and labeling requirements are also provided. Labels indicating compliance with the standard are mandatory on impact-protective systems (IPS). The requirements also dictate what information must be shown on labels.
- The standard provides limitations on joints, gaps, voids, and penetrations in the storm shelter envelope. Where the limitations are exceeded, opening protection is required.
- Foundations and slabs that support a residential storm shelter within one- or two-family dwellings must be designed in accordance with either American Concrete Institute (ACI) 318, *Building Code Requirements for Structural Concrete*, or ACI 332, *Code Requirements for Residential Concrete and Commentary*, for all applicable loads of ICC 500 Chapter 3. All other storm shelters must comply with ACI 318 for all applicable loads of ICC 500 Chapter 3. An exception for existing slabs supporting heavy storm shelters is included.

2.3. Siting

- The standard provides criteria based on the storm shelter type and the location of the shelter in three defined flood hazard areas so that users can determine whether Chapter 4 flood design requirements and minimum floor elevations apply.
- Flood siting restrictions that apply to all storm shelters are also provided. An additional siting restriction is the maximum travel distance for residential tornado storm shelters. Also, a reference is provided to IBC Section 423 for maximum travel distance to community storm shelters that are required for educational occupancies.

2.4. Occupant Density, Entry, Accessibility, Egress, and Signage

- ICC 500 provides storm shelter occupant density tables with minimum usable floor area per occupant along with criteria for determining usable floor area.
- Provisions for community storm shelter entry and egress include accessibility, egress doors, emergency escape openings, and requirements unique to multi-story shelters. Simplified entry and egress requirements are provided in a separate section for residential storm shelters. Both sections reference the same free-standing section for vertical access and egress requirements where emergency stairs, ladders, or alternating tread devices are used to meet access and egress requirements.
- The standard also provides latching mechanism requirements for IPS to address engagement of the system, multi-latching systems, operating hardware, and egress.
- Storm shelter signage requirements are provided to ensure the protected areas are easily identifiable and readily located.

2.5. Fire Safety

- Where they are required for the normal use of the storm shelter, fire protection systems are not required to be protected from the storm shelter design event.
- The standard provides fire-resistant rated construction requirements (including exceptions) for community storm shelters.
- Fire extinguisher requirements are also provided for community storm shelters.

2.6. Essential Features and Accessories

- ICC 500 includes tables showing the number of required water closets and lavatories for both hurricane and tornado storm shelters. Community storm shelters with design occupant capacities of greater than 50 are also required to provide a sanitation support method capable of supplying water and containing (or disposing of) waste.
- Drinking water requirements per occupant are provided for community hurricane storm shelters.
- The standard also provides rainfall drainage requirements for hurricane storm shelters, which are based on enhanced rainfall rates.
- Natural and mechanical ventilation requirements are covered for tornado and hurricane storm shelters. Tornado storm shelters are permitted to be ventilated by natural or mechanical means. Hurricane shelters must have natural ventilation, and those with a design occupant capacity of 50 or more must also have mechanical ventilation.
- The standard also covers requirements for other storm shelter critical support systems, such as emergency lighting, standby lighting, and standby power. To maintain functionality throughout the design storm event, storm shelter critical support systems located outside the shelter envelope must be protected from wind loads, tornado loads, debris impact, and flood loads (where applicable) to the same level as the storm shelter.

2.7. Test Methods

- The standard specifies missile impact and pressure (static and cyclic) testing method requirements for storm shelters and storm shelter components.
- Pass/fail criteria and recordkeeping requirements for the required storm shelter testing are also provided.

2.8. Storm Shelter Preparedness and Emergency Operations

- The standard provides Appendix A to facilitate development of preparedness and emergency operations plans, which are required (see Section 109, Owner's Responsibility) for all community storm shelters.

- Although ICC code and standard appendices are only mandatory where specifically adopted by the authority having jurisdiction (AHJ), ICC 500 Appendix A may serve as a template for the development of a preparedness and emergency operations plan even where it is not adopted.

3. Significant Changes in the 2023 Edition of ICC 500

The 2023 edition of ICC 500 features several overall changes intended to enhance consistency and organization within the standard and provide better correlation with the applicable codes.

Cumulatively, the following revisions should improve the user experience for designers, code officials, owners/operators, builders/contractors, and, ultimately, the storm shelter occupants.

- Throughout the standard, tornado shelter design “wind speeds” and “wind loads” terminology from earlier editions are changed to “tornado speeds” and “tornado loads” for consistency with ASCE 7-22.
- For better overall organization, provisions for “Listing and Labeling” of IPS have been moved from Chapter 1 (Administration and Application) to Chapter 3 (Structural Design and Testing Criteria).
- Similarly, automatic shutoff requirements for hazardous gas or liquid lines that penetrate the storm shelter envelope have been moved from Chapter 3 to Chapter 7 (Essential Features and Accessories). Requirements governing the structural integrity and protection of storm shelter envelope utility penetrations remain under Section 306.4 (Roof and wall openings).

The sections that follow provide a brief representation of the most significant changes by chapter.

3.1. Chapter 1, Application and Administration

- **Section 103, Conventions: Section 103.1, Dimensions**, has been clarified to disallow the application of conventional industry tolerances anywhere dimensional limits are provided as “minimum” or “maximum” (i.e., “minimum” and “maximum” dimensions are absolute limits). The clarification was initiated by the concurrent reformatting of Section 306.4.4 (Joints, gaps or voids in the storm shelter envelope).
- **Section 106, Submittal Documents: Section 106.2, Design information**. In the previous edition of ICC 500, design information Item 21 specified details that must be included in the submittal documents where storm shelters are attached to foundations with post-installed anchors. In ICC 500-2023, the scope of Item 21 has been clarified to apply to prefabricated storm shelters and expanded to cover post-installed anchors used for structural components and IPS.
- **Section 107, Quality Assurance Plan**: This section has been revised to eliminate redundancies such that the resulting plan requirements are substantially unchanged. Additionally, storm shelter contractor’s responsibility requirements were unchanged but moved from Section 107.4 to free-standing Section 110 (Contractor’s Statement of Responsibility).

- **Section 109, Owner’s Responsibility:** This section has been relocated from Section 108 and adds a new community storm shelter requirement for submittal of a written evaluation and maintenance plan in accordance with Section 113 (see change details below) to the AHJ. The evaluation and maintenance plan submittal requirement expands on the requirement for submittal of a preparedness and emergency operations plan to the AHJ, which was added to ICC 500-2020.
- **Section 113, Evaluation, Maintenance and Repairs:** This section adds a new requirement for storm shelter owners to develop and maintain a written evaluation and maintenance plan (NEW Section 113.2) and augments the existing criteria for evaluations, maintenance, and repair of storm shelter walls, roof, and IPS throughout Section 113 with new requirements that cover storm shelter critical support systems.

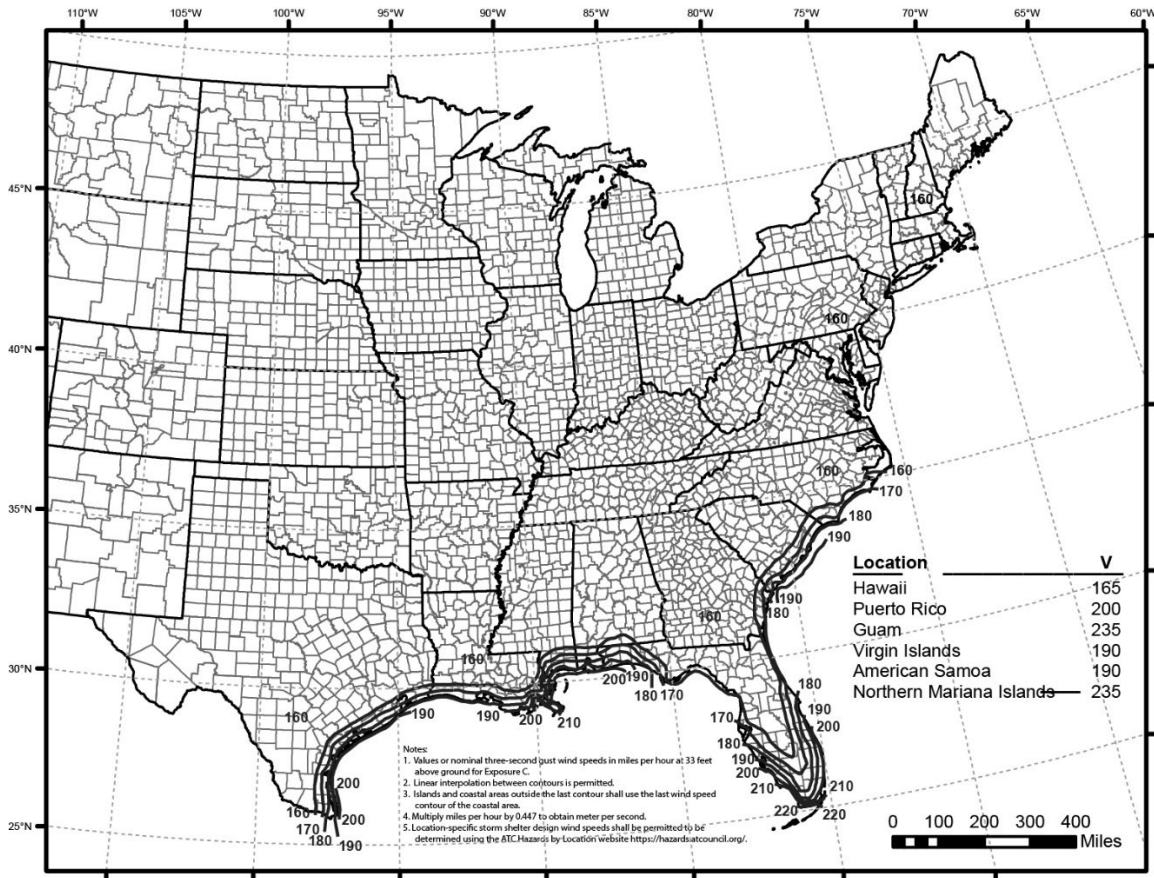
3.2. Chapter 3, Structural Design and Testing Criteria

The most significant changes to ICC 500-2023 were related to updating the referenced edition of ASCE 7 from 2016 to 2022. Although references to Chapter 3 occur across the standard, all ASCE 7 coordinated changes to ICC 500-2023 (aside from the introduction of “tornado speed” and “tornado load” terminology) are within Chapter 3. Unlike the previous two updates to ICC 500, there were no changes to the hurricane storm shelter design wind speed map, which has been retained from the 2020 edition as shown in Figure 2.

- **Section 301, General**
 - **NEW Section 301.4, Performance based design for tornado loads:** This new section adds a performance-based design (PBD) option for tornado storm shelters provided that the storm shelter design loads resulting from the PBD are not less than the minimum loads required by ICC 500. Determination of the PBD wind loads is referenced to new ASCE 7-22 Section 26.1.3.
 - **NEW Section 301.5 Performance based design for wind loads:** This new section adds a PBD option for hurricane storm shelters provided that the storm shelter design loads resulting from the PBD are not less than the minimum loads required by ICC 500. Determination of the PBD tornado loads is referenced to new ASCE 7-22 Section 32.1.3.
- **Section 302, Load Combinations:** This section of ICC 500-2023 modifies the storm shelter load combinations to be utilized in addition to those provided in the applicable code. It also decreases the load factor for rain load on hurricane shelters in Sections 302.2, Strength Design, and 302.3, Allowable Stress Design to reflect that the prescribed rain loads are ultimate level loads rather than service-level loads (previous editions of the standard were overly conservative). As a result, the rain load factors were reduced in Section 302 while the rain load requirements for hurricane shelter roofs in Section 303.1 were retained.

- **Section 304, Tornado Loads and Wind Loads:** Modifications to this section primarily serve to coordinate ICC 500-2023 with updates to ASCE 7-22 wind load criteria and the new tornado load requirements in Chapter 32 of ASCE 7-22.
 - **FORMER Section 304.5, Topographic effects:** The former section was deleted because ASCE 7-22 Chapter 32 does not apply topographic effects to determine tornado loads.
 - **CURRENT Section 304.5, Exposure category:** Requirements for hurricane storm shelters were substantively unchanged, but exposure category requirements for tornado shelters were removed because ASCE 7-22 Chapter 32 does not apply exposure category to determine tornado loads.
 - **Section 304.9, Storm shelters connected to host buildings:**² The requirement that storm shelters be designed to resist the maximum force transmissible from any connected “host element or component” has been descoped to specifically address “structural element” connections between the host building and shelter. In approving the change, the committee noted that the main concern for storm shelter design is the loads that connected structural elements could transfer to the storm shelter.

² Refer to FEMA Funding Criteria in Part B of FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, Fifth Edition, 2024, for additional requirements that apply whenever a safe room is constructed with FEMA grant funds.



SOURCE: ICC 500 (2023) FIGURE 304.3(1); USED WITH PERMISSION

Figure 2: Design wind speeds for hurricane storm shelters

- **Section 306, Storm Shelter Envelope Component Design and Testing:**
 - **Section 306.4.1.4, Door undercut:** This section was clarified with revised text and a new figure to better convey how the existing maximum 3/4-inch door undercut is to be determined. Further, a new requirement was added that limits the gap between meeting pairs of doors in the storm shelter envelope to a maximum of 3/16 inch.
 - **NEW Section 306.4.1.5, Louvers:** The new IPS subsection provides performance criteria for louvers installed in the storm shelter envelope and points to the applicable Chapter 8 test method requirements.

3.3. Chapter 4, Siting

No changes were made to Chapter 4, Siting, in ICC 500-2023.

3.4. Chapter 5, Occupant Density, Entry, Accessibility, Egress and Signage

- **Section 504, Entry and Egress in Community Shelters: Section 504.5, Emergency escape opening**, has added requirements to decrease the probability of both the emergency escape opening and egress door being blocked by post-storm debris. The first requires the opening be located on an opposite wall, perpendicular wall, roof, or floor from the means of egress door “where practicable.” The second requires the opening and the egress door be separated by a distance of at least one-third the overall diagonal dimension of the shelter as measured horizontally between any point on the two openings. Similar language has been added to Section 504.6, Overhead hatches.
- **Section 507, Latching**
 - **NEW Section 507.5, Electronic operating hardware**: This section has been added to require that shelter occupants have the ability to secure IPS where latching or locking is electronically controlled. The change was implemented to address storm shelters that can be unlocked remotely to allow occupants entry as soon as the shelter is activated as described in FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, Fifth Edition, 2024, Section A4.5.2.
 - **NEW Section 507.6, Egress**: This section was added to require that latching or locking mechanisms on IPS protecting ICC 500-required egress openings not prohibit occupants from egressing the storm shelter. For example, a padlock installed on the exterior side of a storm shelter door would be disallowed.

3.5. Chapter 6, Fire Safety

- **Section 603.1, Fire separation**:³ This section was updated in ICC 500-2020 to (1) clarify that walls and horizontal assemblies between community storm shelters and other host building areas must have a minimum 2-hour fire-resistance rating, and (2) provide exceptions where the 2-hour minimum rating can be waived. ICC 500-2023 has been modified so that exception #3, which applies to community storm shelters with design occupant capacities less than 50, only requires one means of egress provided that it opens directly to the exterior of the storm shelter. Previously, the means of egress that opened directly to the exterior were required to be in addition to the primary means of egress, so that a minimum of two means of egress were required.
- **Section 604, Fire Extinguishers: Section 604.2, Requirements**, has been updated to require that community storm shelter fire extinguishers be provided in accordance with IBC Section 906 (Portable fire extinguishers), whereas previous editions were required to comply with the National

³ Refer to FEMA Funding Criteria in Part B of FEMA P-361 for additional requirements that apply whenever a safe room is constructed with FEMA grant funds.

Fire Protection Association's (NFPA's) standard NFPA 10. Although IBC Section 906 references NFPA 10, it also includes additional requirements that apply to storm shelters.

3.6. Chapter 7, Essential Features and Accessories

Chapter 7 was reformatted so that standby power requirements for tornado storm shelters (Section 702) and hurricane storm shelters (Section 703) follow sections with requirements for ventilation and lighting, which inform minimum standby power capacity.

- **Sections 702.2 (Tornado) and 703.2 (Hurricane), Protection of storm shelter critical support systems:** These formerly combined requirements were relocated from Section 701.2 to 702.2 (Tornado) and 703.2 (Hurricane) to provide storm-specific criteria on minimum system functionality durations (same as minimum period of shelter occupancy) while creating the possibility for divergent criteria in future editions.
- **Section 702.4, Water closets and lavatories**
 - **NEW Section 702.4.4, Sanitation support method:** This new section has added back criteria for sanitation support systems that were removed for tornado shelters in ICC 500-2020 due to cost concerns and the relatively short minimum period of occupation. The revised section no longer requires wastewater storage capacity (as in ICC 500-2014) but parallels updated hurricane shelter sanitation support method requirements.
 - **NEW Section 702.4.4.1, Storage capacity for water supply and wastewater:** This new section specifies the storage capacity for water that must be kept available for plumbing and waste disposal systems in the event that the water supply to shelter sanitation systems is lost. The requirement applies to community tornado shelters with design occupant capacities of 50 or greater and provides an exception for the specified minimum quantities to be reduced (proportional to the total number of water closets and lavatories required) where temporary water closets and lavatories are provided. To address shorter minimum periods of occupancy in tornado shelters, the required total storage water capacity is one-twelfth the amount for community hurricane shelters (i.e., 2 hours divided by 24 hours equals one-twelfth).
- **Section 702.5, Ventilation: Section 702.5.2, Mechanical ventilation:**⁴ The minimum mechanical ventilation rate of 5 cubic feet per minute per occupant was introduced in ICC 500-2020 for both tornado and hurricane storm shelters that rely on mechanical ventilation to meet ICC 500 ventilation requirements. Based on the shorter minimum duration of occupancy in tornado shelters, the minimum mechanical ventilation rate has been reduced to 2.5 cubic feet per minute per occupant for tornado shelters only.

⁴ Refer to FEMA Funding Criteria in Part B of FEMA P-361 for additional requirements that apply whenever a safe room is constructed with FEMA grant funds.

- **FORMER Section 703.3.5, Location:**⁵ This former Chapter 7 section requiring the accessway between the community hurricane storm shelter and the shelter's required standby power system be protected to the same criteria as the shelter was removed primarily because of concerns over cost and potential site-related design challenges.

3.7. Chapter 8, Test Methods for Impact and Pressure Testing

- **Section 803, Impact Testing:**
 - **Section 803.9.1, Panel or framed wall assemblies and roof assemblies:** This section has been clarified to address required impact locations where vertical studs or supports are located at the horizontal center of the tested assembly. Further clarifications cover impact criteria at interface joints.
 - **Section 803.9.5, Window assemblies and other glazed openings:** This section has been modified to require that where the tested assembly includes a lock/latch, the designated corner impact must occur nearest the lock/latch. Further, additional impacts are now required wherever the test assembly includes interface hinge joints and primary latches.
 - **Section 803.9.6, Other impact-protective system assemblies:** In this section, the required missile impact locations have been clarified, and new criteria have been added to address how panel assemblies with seams or laps and hinged or pivoted assemblies must be tested.
 - **Section 803.10, Pass or fail: NEW Section 803.10.5, Maximum deflection,** adds new impact testing pass/fail criteria that prohibit perforation of the witness screen by the deflected test specimen. If the tested IPS is intended to be installed on the exterior of the protected component (e.g., shutter), then the tested component's maximum deflection must be less than the distance between the IPS and protected component.
 - **NEW Section 803.11, Minimum reporting requirements:** This new section provides reporting criteria for storm shelter impact testing.
- **Section 805, Static and cyclic pressure testing procedures:**
 - **NEW Section 805.4, Pass or fail:** This new section provides pass/fail criteria for storm shelter pressure testing, including pressure resistance, permanent deformation, and maximum deflection. The first three editions of ICC 500 included pass/fail criteria for impact testing only.
 - **NEW Section 805.5, Minimum reporting requirements:** This new section provides reporting criteria for storm shelter pressure testing.

⁵ Refer to FEMA Funding Criteria in Part B of FEMA P-361 for additional requirements that apply whenever a safe room is constructed with FEMA grant funds.